NATIONAL SCIENCE FOUNDATION

FY 2016 Budget Request to Congress

February 2, 2015

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NSF FY 2016 Budget Request to Congress

*The National Science Foundation Act of 1950 (Public Law 81-507) sets forth our mission: "**To promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense..."***

*The National Science Foundation Strategic Plan for 2014-2018, "Investing in Science, Engineering, and Education for the Nation's Future," defines our vision: "**A Nation that creates and exploits new concepts in science and engineering and provides global leadership in research and education."***

This FY 2016 Budget Request for the National Science Foundation (NSF) continues NSF's longstanding commitment to making investments in learning and discovery that will grow our economy, sustain our competitive advantage, and enable America to remain the world leader in innovation. It embraces the challenge of ensuring that scientific discovery and technological breakthroughs remain engines for expanding the frontiers of human knowledge and responding to the challenges of the 21st century.

NSF's FY 2016 Budget Request is $7.724 billion, an increase of $379.34 million (5.2 percent) over the FY 2015 Estimate. This reflects a strong commitment from the Administration to support science and engineering broadly, as well as the people that keep our Nation's scientific enterprise at the forefront of knowledge and discovery.

FY 2016 Budget Request

Total: $7.724 billion

Increase: $379.34 million

5.2% over FY 2015

In turn, NSF is committed to a careful and continuous evaluation of its portfolio to maximize efficiency, effectiveness, and return on investment. This ensures that the agency establishes clear priorities, and it also fosters the development of innovative mechanisms for achieving its investment goals. NSF also works to leverage resources, infrastructure, networks, and data across the federal government and invest in promising collaborative international opportunities.

FY 2016 Cross-Foundation Investments

NSF continues to bring together researchers from all fields of science and engineering to address today's cross-disciplinary questions and challenges through Foundation-wide activities. In FY 2016, four priority investments address issues of major scientific, national, and societal importance.

Funding for FY 2016 Cross-Foundation Investments

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	FY 2016 Request Change Over FY 2015 Estimate Amount	FY 2016 Request Change Over FY 2015 Estimate Percent
Understanding The Brain (UtB)	$92.62	$106.44	$143.93	$37.49	35.2%
Risk and Resilience	-	20.00	58.00	38.00	190.0%
Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS)	-	-	74.96	74.96	N/A
Inclusion across the Nation of Communities of Learners that have been Underrepresented for Diversity in Engineering and Science (NSF INCLUDES)	-	-	15.00	15.00	N/A

Understanding the Brain (encompasses ongoing cognitive science and neuroscience research and NSF's contributions to the Administration's Brain Research through Advancing Innovation and Neurotechnologies (BRAIN) Initiative. The goal of the Understanding the Brain investment is to enable scientific understanding of the full complexity of the brain in action and in context. Priorities include: development of innovative technologies, tools and instrumentation, computational infrastructure, theory, and models to understand the brain; increased understanding of relationships between neuronal activity, cognitive processes, and behavior; exploration of links between environment, behavior, and brain function; and training for the next generation of neuroscientists and neuroengineers. Improved understanding of the brain will promote brain health; enable engineered solutions that enhance, replace or compensate for lost function; improve the effectiveness of formal and informal educational approaches; and lead to brain-inspired smarter technologies for improved quality of life. Basic research in these areas can provide novel insights into how cognitive abilities develop and can be maintained and improved throughout the lifespan.

NSF In Action

The Center for Brains, Minds, and Machines (CBMM) at the Massachusetts Institute of Technology supports both NSF's cognitive science and neuroscience investments, as well as the BRAIN Initiative, through cross-disciplinary efforts to build more human-like machines, with the goal of establishing a theory of intelligence. CBMM will also help train the next generation of scientists and engineers through a variety of workshops and courses, an activity directly aligned with one of the goals of Understanding the Brain.

NSF In Action

How can we better predict and respond to natural hazards, as well as develop the resilient infrastructure critical for bouncing back from extreme events? NSF-funded researchers are working on topics such as the integration of natural, human and infrastructure systems for hurricane evacuation and sheltering; volcanic crises in the United States; next-generation warning systems for tornadoes and flash floods; and magnitude 9 earthquake scenarios: modeling, warnings and responses. In addition, researchers are also investigating innovative ways to bolster the resilience of the electrical grid, water systems, and other lifelines and services by exploring interactions between natural gas and electricity systems, power and communication networks, healthcare, and cyber infrastructure. These activities are funded through the Resilient Interdependent Infrastructure Processes and Systems pilot program and the Hazards and Disasters component of Science, Engineering, and Education for Sustainability (SEES), and are examples of the types of research efforts that the new Risk and Resilience investment will be based upon.

Risk and Resilience investments aim to improve predictability and risk assessment and increase resilience to extreme natural and man-made events in order to reduce their impact on quality of life, society, and the economy. NSF is uniquely positioned to support such improvements that require multidisciplinary expertise in science, engineering, and education, such as understanding the dynamic processes that produce extreme events, how people respond to extreme events, and how to engineer resilient infrastructure. One supporting program is Critical Resilient Interdependent Infrastructure Systems and Processes, which directly addresses the need for the resilient and reliable infrastructure that is critical to U.S. economic competitiveness and national security. Another is Prediction of and Resilience against Extreme Events, which aims to enhance the understanding and prediction of, as well as resilience and sustainable responses to, extreme events and geohazards, as well as their impact on natural and human systems.

Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS) is an NSF-wide investment that aims to understand, design, and model the interconnected food, energy, and water system through an interdisciplinary research effort that incorporates all areas of science and engineering and addresses the natural, social, and human-built factors involved. Throughout NSF, activities address food, energy, or water, such as the SEES portfolio, particularly Water Sustainability and Climate and Hazards SEES; Coupled Natural and Human Systems; and Basic Research to Enable Agricultural Development. INFEWS, however, will be the first program to study the interconnected food-energy-water nexus. The need for this program is increasingly urgent, as growing U.S. and global populations, changes in land use, and increasing geographic and seasonal variability in precipitation patterns are placing an ever-increasing stress on these

NSF In Action

The Great Lakes are a vital freshwater resource with chronic water quality problems. A team of investigators led by Stanford and the University of Michigan is looking at eutrophication (a process whereby water bodies receive excess nutrients that stimulate excessive plant growth) and nutrient loading, specifically phosphorus, in the Great Lakes. This research addresses the effects of modern agricultural practices and weather-related events on water quality and freshwater ecology (including fisheries), with a goal of informing effective management strategies for fertilizer application. This activity is funded through NSF's Water Sustainability and Climate program, and is an example of the type of water research that INFEWS will build upon to address the larger food-energy-water nexus.

critical resources. NSF, through INFEWS, is uniquely poised to focus not only on the fundamental science and engineering questions at this nexus, but to train the next generation of researchers in this interdisciplinary area.

NSF in Action

With NSF support, The Council on Undergraduate Research (CUR) has engaged in a systematic effort to enhance the capacity of community colleges to support faculty sponsorship of undergraduate research across all STEM disciplines. Following the development of a curriculum aimed at community college faculty and creation of a cadre of faculty leaders, CUR conducted thirteen workshops bringing together teams of faculty from community colleges to learn about creating and sustaining undergraduate research activity. Over 100 community colleges have participated in these workshops followed by a national conference to enable participants to share results of initial successes at their local campuses. A monograph, Tapping the Potential of All: Undergraduate Research at Community Colleges, was produced with chapters from participants in the project that has been widely shared across the nation's community colleges.

A new approach, **NSF INCLUDES (Inclusion across the Nation of Communities of Learners that have been Underrepresented for Diversity in Engineering and Science)**, is an integrated, national initiative to increase the preparation, participation, advancement, and potential contributions of those who have been traditionally underserved and/or underrepresented in the science, technology, engineering, and mathematics (STEM) enterprise. Following wide community engagement in FY 2015, FY 2016 efforts will focus on the development of a set of new scalable concepts that will provide focus for collaborative action. Our investments are intended to produce rapid progress on changing the balance of diversity in S&E, have significant national impact for the participation of underrepresented groups, stimulate the community, forge new partnerships, and catalyze new approaches. NSF INCLUDES will build on and amplify NSF's nearly $800 million investment portfolio in broadening participation.

FY 2016 Ongoing NSF-Wide Priorities

NSF addresses many of the complex issues that face the Nation today through interdisciplinary science, engineering, and educational activities. Foundation-wide programs and priorities bring together researchers from all fields of science and engineering to focus on these challenges from a myriad of perspectives, methodologies, and knowledge bases. These interdisciplinary investments are carefully balanced with a longstanding commitment to the fundamental research that addresses grand challenges and furthers basic scientific knowledge.

FY 2016 Funding for Ongoing NSF-Wide Priorities

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	FY 2016 Request Change Over FY 2015 Estimate Amount	Percent
Clean Energy Technology	$351.07	$370.00	$377.22	$7.22	2.0%
Cyber-Enabled Materials, Manufacturing and Smart Systems (CEMMSS)	255.94	231.46	256.95	25.49	11.0%
Advanced Manufacturing	*188.30*	*164.73*	*176.57*	*11.84*	7.2%
Cyberinfrastructure Framework for 21st Century Science, Engineering, and Education (CIF21)	156.75	128.96	143.06	$14.10	10.9%
Innovation Corps (I-Corps™)	20.49	26.23	30.00	$3.77	14.4%
NSF Research Traineeship (NRT)[1]	33.40	61.55	62.01	$0.46	0.7%
Research at the Interface of Biological, Mathematical, and Physical Sciences (BioMaPS)	37.47	29.27	32.81	$3.54	12.1%
Science, Engineering, and Education for Sustainability (SEES)	164.49	139.00	80.50	-58.50	-42.1%
Secure and Trustworthy Cyberspace (SaTC)	126.00	122.75	124.25	1.50	1.2%

[1] Outyear commitments for Integrative Graduate Education and Research Traineeship (IGERT) are included in the NRT line and are $32.81 million in FY 2014, $12.12 million in FY 2015, and $10.33 million in FY 2016.

- **Clean Energy Technology** ($377.22 million) investments are driven by the fundamental research questions that underlie future energy pathways. NSF's clean energy investments support research and education in alternative energy for electricity (solar, wind, wave, geothermal) and fuels (chemical and biofuels). NSF funding also addresses the collection, conversion, storage, and distribution of energy from diverse power sources, including smart grids; the science and engineering of energy materials; energy use; and energy efficiency. Clean energy research addresses our advancement toward reliable and sustainable energy resources and systems that preserve essential ecosystems and environmental services, promote positive social and economic outcomes, and prepare society to responsibly adopt them.

- **Cyber-enabled Materials, Manufacturing, and Smart Systems (CEMMSS)** ($256.95 million) aims to integrate a number of science and engineering activities across the Foundation – breakthrough materials, advanced manufacturing, robotics, and cyber-physical systems. It will address pressing technological challenges facing the Nation and promote U.S. manufacturing competitiveness. In FY 2016, CEMMSS continues to leverage key interagency activities, including the Administration's Materials Genome Initiative, Advanced Manufacturing Partnership, and the National Robotics Initiative. Through CEMMSS, NSF also invests in Advanced Manufacturing ($176.57 million).

- **Cyberinfrastructure Framework for 21st Century Science, Engineering, and Education (CIF21)** ($143.06 million) accelerates and transforms the process of scientific discovery and innovation by providing advanced cyberinfrastructure and new capabilities in computational and data-enabled science and engineering. In FY 2016, NSF will continue to lead the Big Data/National Data Infrastructure program, a joint solicitation with the National Institutes of Health that strives to enable breakthrough discoveries and innovation in science, engineering, medicine, commerce, education, and national security.

- **Innovation Corps (I-Corps™)** ($30.0 million) improves NSF-funded researchers' access to resources that can assist in bridging the gap between discoveries and downstream technological applications. In FY 2016, NSF will continue to support I-Corps™ Nodes and I-Corps™ Sites to further build, utilize, and sustain a national innovation ecosystem that augments the development of technologies, products, and processes that benefit the Nation.

- **NSF Research Traineeships (NRT)** ($62.01 million) in its third year, continues to identify priority research themes that both align with NSF priority research activities and have strong potential in areas of national need where innovative practices in graduate education can be developed. NRT investments aim to advance the research agenda of these themes, as well as develop and conduct research on new approaches and models for educating the next generation of scientists and engineers.

- **Research at the Interface of Biological, Mathematical, and Physical Sciences (BioMaPS)** ($32.81 million) involves the Directorates for Biological Sciences, Mathematical and Physical Sciences, and Engineering, and it seeks to advance discovery at the intersections of these established disciplines. Research includes activities such as development of models, informed by statistical physics that establish the mechanisms linking the biological function of chromosomes to their cellular structure.

- **Science, Engineering, and Education for Sustainability (SEES)** ($80.50 million) aims to increase understanding of the integrated system of supply chains, society, the natural world, and alterations humans bring to Earth, in order to create a sustainable world. In FY 2016, SEES continues to ramp down in anticipation of a planned FY 2017 sunsetting; however, SEES continues to support important scientific and societal contributions during the phase-down period and will make significant progress towards achieving programmatic goals through projects currently underway. The success of several SEES research programs motivates new FY 2016 investments in INFEWS and Risk and Resilience.

- The **Secure and Trustworthy Cyberspace (SaTC)** investment ($124.25 million) aims to build the knowledge base in cybersecurity that enables discovery, learning and innovation, and leads to a more secure and trustworthy cyberspace. Through a focus on long-term, foundational research, SaTC will develop the scientific foundations for cybersecurity research for years to come. SaTC aligns NSF's cybersecurity investments with the four thrusts outlined in the national cybersecurity strategy, *Trustworthy Cyberspace: Strategic Plan for the Federal Cybersecurity Research and Development Program.*

Additional Priorities and Highlights

In FY 2016, NSF continues to emphasize investments in important or emerging areas that have been developed in recent years, including:

- **Synthetic Biology** (approximately $60 million) investments support the design and construction of new biological components as well as the redesign of existing natural biological systems for tailored purposes (e.g., improving the efficiency of photosynthesis for clean energy generation, or introducing the ability of economically important crop plants to fix nitrogen thereby eliminating dependence on

environmentally damaging fertilizers). Also included are investments in the basic biological, physical, and computational sciences and engineering that will enable the construction of a rule set and design tools for synthetic biology (i.e., the rules that govern the construction and function of new biological parts). This portfolio, which promises to develop rapidly emerging technology for new applications and disruptive technology for long-standing problems in food, energy, biomanufacturing, and other areas of national need, spans several NSF directorates as the synthetic biology approach integrates engineering and computer assisted design with biological research. There are also a number of potential partnerships with industry, other federal agencies, and other countries that will be further explored.

- **Urban Science** ($7.50 million) investments will focus on the research and development of critical infrastructure and applications, which address pressing urban challenges, such as sustainability, livability, and equity, through both fundamental research and translational research that is supported via partnerships. Multidisciplinary Urban Science research efforts at NSF and other agencies will address the question of how we can intelligently and effectively design, adapt, and manage cities to maximize their positive potential. It will enable the integration of networked computing systems, physical devices, data sources, and infrastructure leading to smart cities.

- NSF aims to increase the operational efficiency of **U.S. activities in the Antarctic** ($18.50 million) by continuing progress on a multi-year commitment toward more efficient and cost-effective science support as recommended by the U.S. Antarctic Program Blue Ribbon Panel report, *More and Better Science in Antarctica through Increased Logistical Effectiveness*. Emphases include safety and health improvements, and facilities renewal at McMurdo and Palmer stations. Additionally, NSF aims to plan and execute more effective observational approaches to the Antarctic science community, as outlined in the 2011 National Research Council report, *Future Science Opportunities in Antarctica and the Southern Ocean*.

STEM Education

To ensure lasting capabilities to address these disciplinary and interdisciplinary challenges, NSF's educational programs and activities integrate research and education in all fields to engage tomorrow's workforce. These programs target all educational levels and emphasize broadening participation, so that STEM fields become more accessible to all whose imagination has been sparked by science and engineering.

NSF's STEM education investment, centered in the Directorate for Education and Human Resources (EHR), funds activities that support students, teachers, researchers, and the public. In keeping with the Administration's priorities and the strategic goals for STEM education as described in the 2013 National Science and Technology Council report, *Federal Science, Technology, Engineering, and Mathematics (STEM) Education 5-Year Strategic Plan*, NSF's key investments for FY 2016 focus on areas where NSF is the identified lead in STEM education, notably graduate education and undergraduate education, and they also emphasize the need to strengthen foundational STEM education research.

- **Improving Undergraduate STEM Education (IUSE)** ($134.58 million) aims to accelerate the quality and effectiveness of the education of undergraduates in all STEM fields by using decades of research on STEM learning and best practices in education to address challenges across fields as well as within specific disciplines. IUSE priorities are aligned with the four strategic objectives for undergraduate education identified in the federal STEM education strategic plan: increase use of evidence-based practices; increase authentic research experiences for students; improve the recruitment, retention, and STEM degree completion for students in two-year colleges; and address the high rates of failure in introductory college mathematics.

- **EHR Core Research (ECR)** ($103.84 million) remains a top priority. In FY 2016, ECR strengthens investments in and impact on the improvement of STEM learning, teaching, and workforce development, through three key areas: learning and learning environments, broadening participation and institutional capacity, and development of the STEM professional workforce.

- The **CyberCorps®: Scholarships for Service (SFS)** program ($45.0 million) supports cybersecurity education and research at higher education institutions. SFS also focuses on workforce development by increasing the number of qualified students entering the fields of information assurance and cybersecurity, which enhances the capacity of the United States higher education enterprise to continue to produce professionals in these fields to secure the Nation's cyberinfrastructure.

Major Research Equipment and Facilities Construction

In FY 2016, NSF requests funding to continue construction of three projects: the Daniel K. Inouye Solar Telescope, the Large Synoptic Survey Telescope, and the National Ecological Observatory Network. Funding concluded in FY 2014 for two projects, the Advanced Laser Interferometer Gravitational-wave Observatory and the Ocean Observatories Initiative.

- The **Daniel K. Inouye Solar Telescope** ($20.0 million) will enable the study of magneto-hydrodynamic phenomena in the solar photosphere, chromosphere, and corona at unprecedented spatial, temporal, and wavelength resolution to gain information on the creation, interaction, and ultimate annihilation of solar magnetic fields. Determining the role of magnetic fields in the outer regions of the Sun is crucial to understanding the solar dynamo, solar variability, and solar activity, including flares and coronal mass ejections. These can affect civil life on Earth through the phenomena generally described as "space weather" and may have impact on the terrestrial climate. FY 2016 is year eight of an eleven year construction process. By the end of FY 2016, the adjacent Support and Operations building will be completed, site testing of the telescope Enclosure will be finished, and the Coudé Rotator Lab will be installed in the pier. In addition, the Telescope Mount Assembly base erection will begin inside the weathertight Enclosure, along with the start of the electrical installation.

- The **Large Synoptic Survey Telescope** ($99.67 million) will be an 8-meter-class wide-field optical telescope designed to carry out surveys of the entire sky available from its site. LSST will collect nearly 40 terabytes of multi-color imaging data every night for ten years and will produce the deepest, widest-field sky image ever. It will image the entire visible sky twice per week, as well as issue alerts for moving and transient objects within 60 seconds of their discovery. The LSST surveys will result in a comprehensive data set that will enable hundreds of other fundamental astrophysical studies by the entire research community. FY 2016 is year three of a nine year construction process. In FY 2016, work on the lower enclosure will be complete at the LSST site, making it ready for construction of the telescope dome atop that enclosure. Following conclusion of a full bid-and-propose process, the contract for construction of the base facility will be awarded. The first components of the sensor will be delivered to the camera team, with production of the first "raft" of sensors (12K by 12K pixels) nearing completion.

- The **National Ecological Observatory Network** ($80.64 million) will consist of geographically distributed field and lab infrastructure networked via cybertechnology into an integrated research platform for regional to continental scale ecological research. NEON is the first research platform and the only national experimental facility specifically designed to collect consistent and standardized sensor and biological measurements across 106 sites nationwide in close to real-time, enabling basic research on complex phenomena driving ecological change and at the scales appropriate for studying many grand challenge questions in ecology. NEON allows researchers to expand the scale of their research to understand large-scale dynamics affecting ecosystems. FY 2016 is the final year of construction, and this will allow the project to complete civil construction, continue sensor deployment at terrestrial and aquatic locations, expand biological sampling, continue cyberinfrastructure hardware and software deployments in support of sites and domain Support Facilities acceptance, expand operational support systems, and ongoing development of data algorithms and related data release via NEON's web portal.

Major Research Equipment and Facilities Construction Funding

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
Ongoing Projects:			
Daniel K. Inouye Solar Telescope (DKIST)	$36.88	$25.12	$20.00
Large Synoptic Survey Telescope (LSST)	27.50	79.64	99.67
National Ecological Observatory Network (NEON)	93.20	96.00	80.64
Funding Complete:			
Advanced LIGO (AdvLIGO)	14.92	-	-
Ocean Observatories Initiative (OOI)	27.50	-	-
Total, MREFC	**$200.00**	**$200.76**	**$200.31**

Totals may not add due to rounding.

Organizational Excellence

NSF seeks to integrate mission, vision, and core values to efficiently and effectively execute our activities and provide the flexibility and agility required for all aspects of its operations. This goal incorporates a culture of continuous improvement to ensure effective, inclusive, and accountable programs and merit review processes that provide the greatest value for taxpayer dollars.

Staffing

In FY 2016, NSF will work towards full utilization of its established FTE allocations, which are increased from the FY 2015 request to a total of 1,367 to accommodate additional staffing for a Digital Service team and requirements of the DATA Act as noted below. The Foundation recognizes that maintaining staffing levels is vital for managing increasing numbers of proposals and the subsequent increase in workload.

FY 2016 Priorities

In FY 2016, the primary drivers of the increase for the Agency Operations and Award Management (AOAM) account are the headquarters relocation and the 1.3 percent cost-of-living adjustment and related salary and benefit increases. AOAM also supports operational activities to ensure the Foundation has sufficient resources to fully fund ongoing operational requirements and maintain essential services as we approach the transition to the new NSF headquarters. These include strengthening capabilities in human resource management, consistent with the opportunities for action or improvement identified in the FY 2014 Strategic Review. FY 2016 funding also includes equipment and technology costs related to NSF's Headquarters relocation.

In addition, $2.85 million will support NSF's efforts to implement the Digital Accountability and Transparency Act (DATA Act; P.L. 113–101) to include changes in business processes, workforce, or information technology to support high quality, transparent Federal spending information. Further, $1.0 million will fund staffing costs to build a Digital Service team that will focus on transforming the agency's digital services with the greatest impact to citizens and businesses so they are easier to use and more cost-effective to build and maintain. For more information on these activities, see the AOAM chapter.

Organizational Excellence by Appropriations Account

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	FY 2016 Request Change Over FY 2015 Estimate	
				Amount	Percent
Agency Operations and Award Management	$305.95	$325.00	$354.84	$29.84	9.2%
Office of Inspector General	13.84	14.43	15.16	0.73	5.1%
National Science Board	4.25	4.37	4.37	-	-
Program Support:					
Research & Related Activities	100.70	105.91	109.75	3.84	3.6%
Education and Human Resources	14.44	15.71	16.67	0.96	6.1%
Subtotal, Program Support	115.14	121.62	126.42	4.80	3.9%
Total	**$439.18**	**$465.42**	**$500.79**	**$35.37**	**7.6%**

Totals may not add due to rounding.

2014-2018 Strategic Plan and Performance

2014-2018 Strategic Plan

Integral to this submission is the NSF Strategic Plan for 2014-2018: *Investing in Science, Engineering, and Education for the Nation's Future*. The goals and strategies outlined in the plan build on lessons learned from NSF's past successes and continue to uphold NSF's mission: "To promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense...."

The plan presents the following goals, which guide the FY 2016 Budget Request:

- "Transform the Frontiers of Science and Engineering" aims to expand and explore the frontiers of human knowledge to enhance the power of the Nation to meet its challenges, and to create new paradigms and capabilities for scientific, technological, and economic leadership in an increasingly fast-paced, competitive world.

- "Stimulate Innovation and Address Societal Needs through Research and Education" strives to focus NSF's research communities on opening up new avenues to address high priority national challenges, as well as encourages formation of partnerships with industry, other agencies, and international counterparts to leverage resources and build capacity.

- "Excel as a Federal Science Agency" focuses on efficiently and effectively executing the agency's responsibilities and achieving the flexibility and agility required to meet the quickly evolving challenges associated with the first two strategic goals.

Performance Plan

NSF embraces the use of goals to drive performance improvements. For FY 2016, NSF has set seven performance goals so that NSF can strategically monitor and oversee progress being made towards its larger aims. NSF also assesses progress through an annual process of Strategic Reviews of the Objectives in its Strategic Plan. In FY 2016, NSF will perform Strategic Reviews, as well as monitor the following annual goals:

- **Ensure that Key Program Investments are on track:** Progress on investments in NSF INCLUDES, INFEWS, and Understanding the Brain will be monitored using a set of common milestones and indicators.

- **Ensure that Infrastructure Investments are on track:** Ensure program integrity and responsible stewardship of major research facilities at varying stages of their lifecycle. In FY 2016, this involves monitoring the performance of construction projects.

- **Use Evidence to Guide Decisions:** The Foundation will use evidence-based reviews to guide management investments.

- **Make Timely Award Decisions:** NSF aims to inform applicants whether their proposals have been declined or recommended for funding within 182 days, or six months of deadline, target, or receipt date, whichever is later.

- **Foster an Environment of Diversity and Inclusion:** The Foundation seeks to foster an environment of diversity and inclusion while ensuring compliance with the agency's civil rights programs.

- **Evaluate NSF Investments:** Enable consistent evaluation of the impact of NSF investments with a high degree of rigor and independence.

- **Increase the Percentage of Wholly Virtual Panels:** Increase the percentage of proposal review panels that are conducted wholly virtually while maintaining the quality of the merit review process.

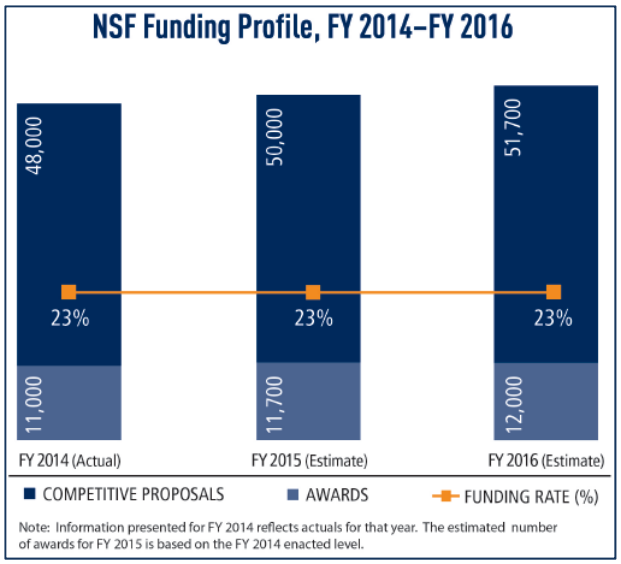
Please refer to performance.gov for information on NSF's agency Priority Goals and NSF's contributions to the federal Cross-Agency Priority (CAP) goals. Agency Priority Goals for FY 2016-FY 2017 will be set as part of the FY 2017 budget process.

NSF's FY 2016 Budget Request includes a change in the per diem compensation for individuals participating virtually in NSF meetings. Per diem compensation will be decreased from the current $280 per day to a new level of $200 per day. For more information on FY 2016 Agency Priority Goals, see the Performance Information chapter.

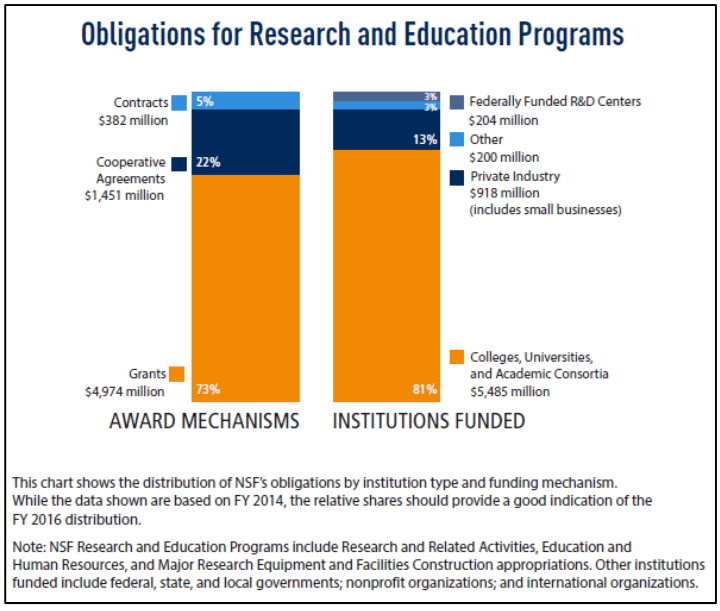
In addition, the Administration is seeking Presidential reorganization authority from the Congress. Under this authority, the President would propose to reorganize Federal business and trade programs, consolidating NSF's National Center for Science and Engineering Statistics and industry partnership programs with related programs in a new department.

NSF by the Numbers

NSF by The Numbers: In FY 2016, NSF expects to evaluate over 51,700 proposals through a competitive merit review process and make over 12,000 new awards. This will require over 225,000 proposal reviews, engaging on the order of 35,000 members of the science and engineering community participating as panelists and proposal reviewers. In a given year, NSF awards reach over 1,800 colleges, universities, and other public and private institutions in 50 states, the District of Columbia, and Puerto Rico. In FY 2016, NSF support is expected to reach approximately 356,000 researchers, postdoctoral fellows, trainees, teachers, and students.



The chart on the right shows the distribution of NSF's obligations by institution type and funding mechanism. While the data are based on FY 2014, the relative shares should provide a good indication of the FY 2016 distribution. As shown on the graph, 95 percent of NSF's FY 2014 projects were funded using grants or cooperative agreements. Grants can be funded either as standard awards, in which funding for the full duration of the project is provided in a single fiscal year, or as continuing awards, in which funding for a multi-year project is provided in increments. Cooperative agreements are used when the project requires substantial agency involvement during the project performance period (e.g., research centers, multi-user facilities, etc.). Contracts are used to acquire products, services, and studies (e.g., program evaluations) required primarily for NSF or other government use.

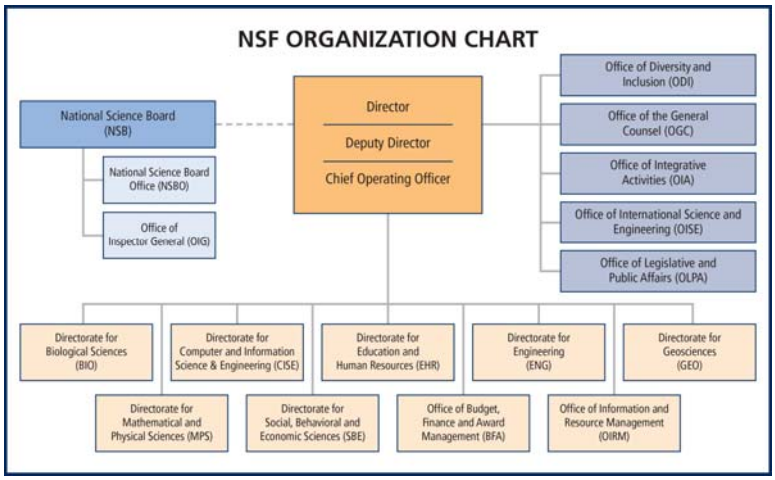


Most NSF awards are to academic institutions. Nonprofit organizations include state and local governments and international organizations. For-profit businesses include private and small businesses. Federal agencies and laboratories include funding for Federally Funded Research & Development Centers.

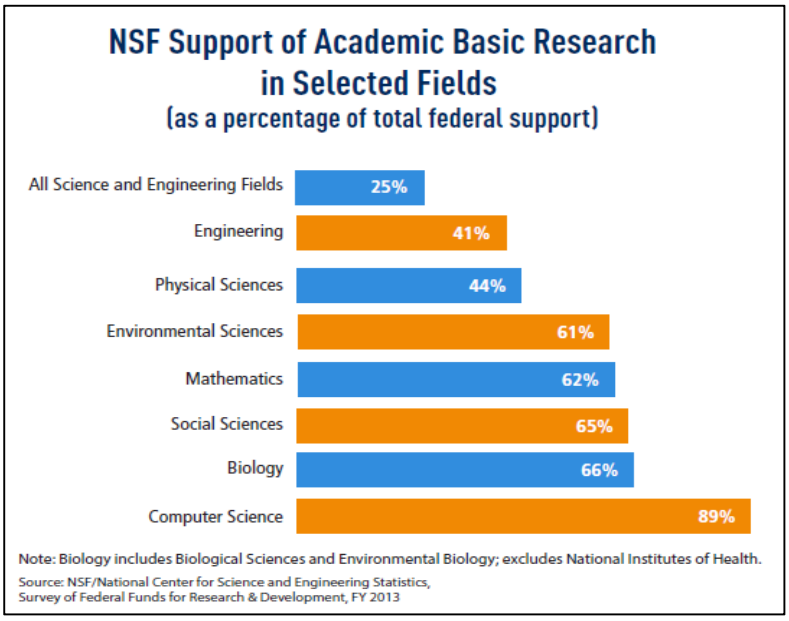
Organization and Role in the Federal Research Enterprise

NSF's comprehensive and flexible support of meritorious projects enables the Foundation to identify and foster both fundamental and transformative discoveries and broader impacts within and among fields of inquiry. NSF has the latitude to support emerging fields, high-risk ideas, interdisciplinary collaborations, and research that pushes – and even creates – the very frontiers of knowledge. In these ways, NSF's discoveries inspire the American public – and the world.

NSF's organization represents the major science and engineering fields, including: biological sciences; computer and information science and engineering; engineering; geosciences; mathematical and physical sciences; and social, behavioral, and economic sciences. NSF also carries out specific responsibilities for education and human resources, cyberinfrastructure, integrative activities, international science and engineering, and polar programs. The 25-member National Science Board sets the overall policies of the Foundation.



This chart reflects the realignment, expected in FY 2015, of the Office of International Science and Engineering (OISE) and Integrative Activities (IA) as separate budget activities.

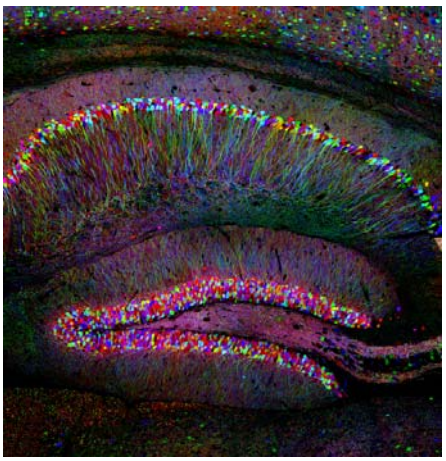


NSF's annual budget represents 25 percent of the total federal budget for basic research conducted at U.S. colleges and universities, and this share increases to 60 percent when medical research supported by the National Institutes of Health is excluded. In many fields NSF is the primary source of federal academic support.

Highlights

For over 60 years, NSF has pursued investments in fundamental research and education to fulfill its mission of promoting the progress of science and engineering. In doing so, NSF supported research has connected the discovery and advancement of knowledge with the potential societal, economic, and educational benefits that are critical for continued U.S. prosperity. Below are just a few of the important recent advances that NSF funding continues to enable.

Memory Making and Protein



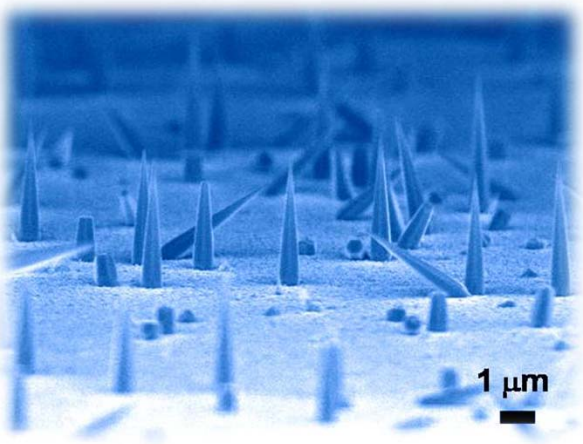
Researchers discovered that the Arc gene and its protein product, also called Arc, play an essential role in memory formation. One of tens of thousands of proteins in the brain, Arc is found in the brain's hippocampus region (the area involved in many forms of learning), and activates as memories form. Knowing how a healthy brain forms memories is an important step to understanding what goes wrong in a range of memory disorders including Alzheimer's disease and stroke.

A fluorescent imaging agent lights up the brain's hippocampus.

Credit: Jean Livet, Institut de la Vision, Paris; Jeff Lichtman and Joshua Sanes, Harvard University

Nanolasers on Silicon

Researchers developed a method to integrate nanolasers on silicon -- a crucial step toward marrying electronic devices and photonic devices (which operate using light). Photonic devices can perform in ways that silicon electronics cannot. For example, optical signals allow computer chips to carry and transmit more data, improving computing speed and efficiency. The miniature lasers could lead to new technologies for signal processing and biochemical sensors as well as cost-effective silicon-based lighting and screens.

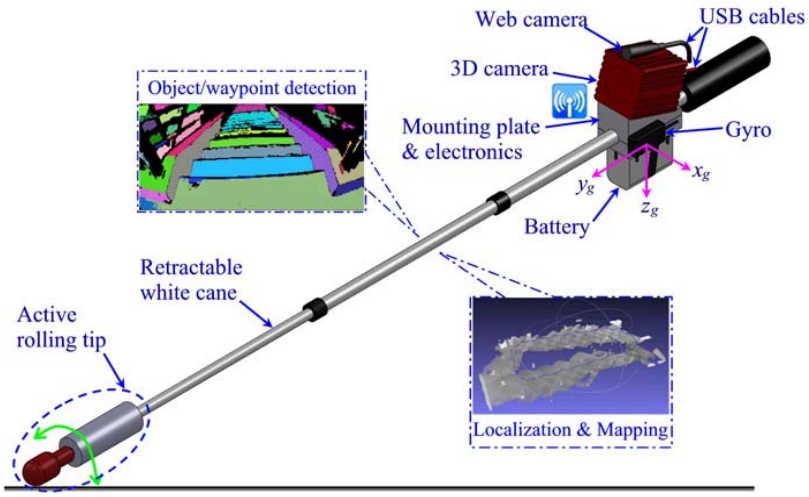


Nanolasers grown on a silicon substrate integrate easily into integrated circuits. Scale: 1 micron.

Credit: Connie Chang-Hasnain, UC Berkeley

Highlights

Seeing-Eye Robot



The co-robotic cane has a rolling tip that points the cane to the desired direction of travel. It is designed to detect the user's intent as well as 3-D objects and to build a working map for the user.

Credit: Dr. Cang Ye, University of Arkansas at Little Rock

At the University of Arkansas at Little Rock, researchers prototyped a robotic walking stick for the blind. It has cameras to detect objects in the way such as chairs and stairs, an audio system that communicates to the user, and a computer that remembers recent pathways and objects in them. Developed under the National Robotics Initiative, a multi-agency program partnership that includes NSF.

New Media Model

"Plum Landing," created by WGBH in Boston, uses animations, games, a mobile app, videos and hands-on activities to increase children's understanding of science and nature. Designed for kids aged 6 to 9, it introduces core science concepts and models key habits of mind scientists use when exploring the natural world. Since its debut last April, the website has garnered 8 million+ page views. Children also are exploring their environments — to date, they've submitted 70,000 photos and drawings.

A girl takes a picture of a plant with the "Plum's Photo Hunt" app on her mobile phone.

Credit: Copyright Bill Shribman

Highlights

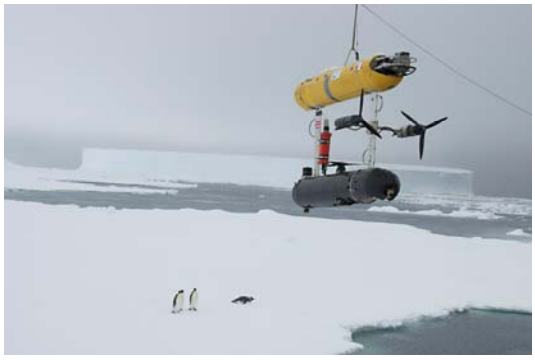
Bionic Suit

The 2014 World Cup kickoff was like no other. A paraplegic volunteer did the ceremonial first kick, wearing an exoskeleton that took cues from his brain activity. The exoskeleton used computer algorithms to detect the brain signals of the kicker, who was wearing an electroencephalography (EEG) cap. The research began nearly two decades ago with an NSF grant to Duke University neurobiologist Miguel Nicolelis for research into how neurons in the cerebral cortex are involved in motor learning.

The exoskeleton's hydraulic pumps power the kicker forward.

Credit: National Science Foundation

Autonomous Underwater Vehicle Ice Study



SeaBED was deployed from the British research vessel James Clark Ross.

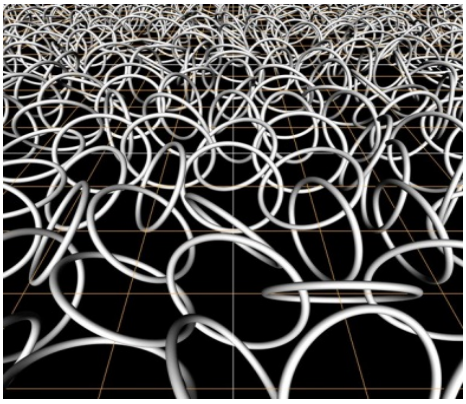
Credit: Hanumant Singh, Woods Hole Oceanographic Institution

Researchers tested an autonomous underwater vehicle, called SeaBED, which can produce high-resolution, 3-D maps of Antarctic sea ice. SeaBED measured and mapped the underside of sea-ice floes in three previously inaccessible areas off the Antarctic Peninsula. The deployment was a big step toward making the routine underwater measurements needed to help monitor and understand changes in sea ice. While satellite observations can tell us about large-scale thickness, interpreting the data can be difficult due to snow cover on the ice. Drilling, as well as visual observations from ships, help fill out the picture, but difficulties getting to thicker areas of sea ice leave gaps in the data. SeaBED is an invaluable tool to fill this gap.

Highlights

Math and Mitochondria

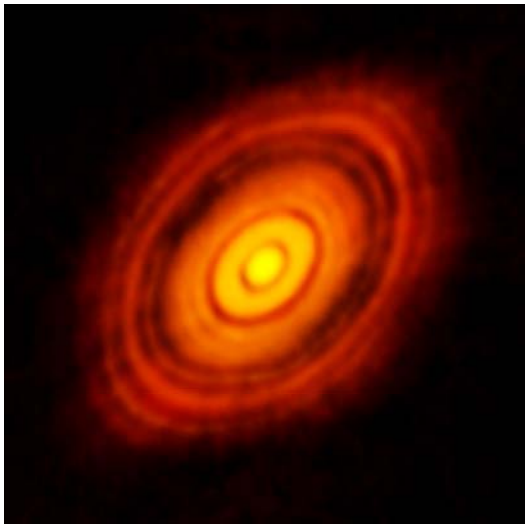
A team of mathematicians used mathematical modeling to uncover new clues to the three-dimensional organization of mitochondrial DNA in trypanosomes. Trypanosomes are microscopic, unicellular parasites responsible for widespread, fatal diseases including sleeping sickness. This neglected disease, transmitted by the tse-tse fly, threatens millions of people in sub-Saharan Africa. Its western counterpart, Chagas disease, affects an estimated 8 to 11 million people across North and South America. Unveiling the intricate organization of DNA in trypanosomes opens new avenues for the design of drugs to prevent and treat these and other diseases.



Network of oriented flat minicircles on a square grid. A tightly packed grid yields high levels of interlocking to form a large network of minicircles. This provides a model for the organization of DNA minicircles in the mitochondria of trypanosomes.

Credit: Javier Arsuaga, San Francisco State University

Atacama Large Millimeter/Submillimeter Array Shows a Planetary System in Formation



Caption: ALMA image of the young star HL Tau and its protoplanetary disk.

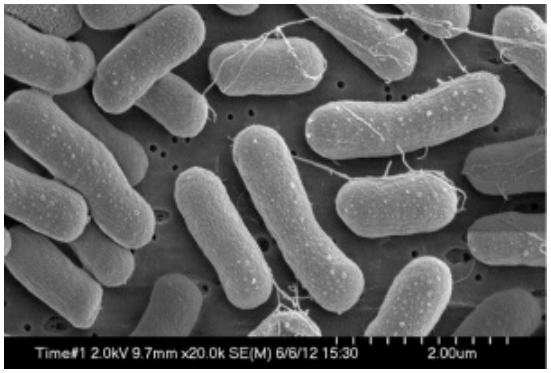
Credit: ALMA (NRAO/ESO/NAOJ); C. Brogan, B. Saxton (NRAO/AUI/NSF)

This image, taken recently with the Atacama Large Millimeter/Submillimeter Array (ALMA), shows a planetary system in the process of formation around a nearby young star called HL Tau. The multiple concentric rings are separated by dark gaps that herald the presence of emerging planets as they sweep their orbits clear of dust and gas. The existence of such well-delineated structures so early in the star's life is challenging our theories of star and planet formation. The image was obtained using only a 30-element subset of the full 66-antenna array as part of early science tests. With the relocatable antennas deployed at almost their maximum separation (15km apart), the spatial resolution is 5 au (1 au is the Earth-Sun distance) at the observing wavelength of 1.3mm.

Highlights

Biodegradable Plastic from Methane

Scientists at Stanford University and a Palo Alto, Calif.-based start-up company called Mango Materials have come up with a new way to make PHA (poly-hydroxyalkanoate) from waste methane gas. PHA is a biodegradable polymer similar to the polypropylene used to make plastic packaging. With funding from the U.S. National Science Foundation, Mango Materials is advancing the process toward commercialization.



Mango Materials is using bacteria like these to create biodegradable plastics.

Credit: Image courtesy of Mango Materials

Tide Data

Hurricane Sandy flooding Avenue C at East 6th Street in Manhattan's East Village.

Credit: David Shankbone/Wikimedia Commons

When 'Superstorm' Sandy blew ashore in 2012, New York City's South Manhattan Seawall protected the island from the storm surge. After analyzing historical tide data, researchers found that the likelihood of water overtopping the seawall is now at least 20 times greater than it was 170 years ago. The findings suggest that the changes in storm tides are related to changes in climate, as well as effects from human activity such as modifying natural channels and limiting peak river flows. This work and similar findings in coastal cities around the U.S. could help municipalities plan for the impact of major storms.

Non-contact detection of explosive materials

In research relevant to homeland security and antiterrorism efforts, Cornell University researchers created an ultrasensitive polymer that uses fluorescence to detect explosives not only on surfaces but in the air. Currently, to identify explosive ingredients, airport security officers run a swab over a suspected object prior to analysis.

Glowing polymer goes dark when exposed to explosive vapors.

Credit: Deepti Gopalakrishnan and William Dichtel

SUMMARY TABLES

Total NSF Funding:

Major NSF-wide Investments:

Education:

Research Infrastructure:

National Science Foundation
Summary Table
FY 2016 Request to Congress

(Dollars in Millions)

NSF by Account	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	FY 2016 Request over: FY 2014 Actual Amount	FY 2014 Actual Percent	FY 2015 Estimate Amount	FY 2015 Estimate Percent
BIO	$720.84	$731.03	$747.92	$27.08	3.8%	$16.89	2.3%
CISE	892.60	921.73	954.41	61.81	6.9%	32.68	3.5%
ENG	833.12	892.31	949.22	116.10	13.9%	56.91	6.4%
Eng Programs	*673.13*	*715.20*	*754.86*	*81.73*	*12.1%*	*39.66*	*5.5%*
SBIR/STTR	*159.99*	*177.11*	*194.36*	*34.37*	*21.5%*	*17.25*	*9.7%*
GEO	1,321.32	1,304.39	1,365.41	44.09	3.3%	61.02	4.7%
MPS	1,267.86	1,336.72	1,366.23	98.37	7.8%	29.51	2.2%
SBE	256.84	272.20	291.46	34.62	13.5%	19.26	7.1%
OISE[1]	48.31	48.52	51.02	2.71	5.6%	2.50	5.2%
IA[1]	433.12	425.34	459.15	26.03	6.0%	33.81	7.9%
U.S. Arctic Research Commission	1.30	1.41	1.48	0.18	13.5%	0.07	5.0%
Research & Related Activities	**$5,775.32**	**$5,933.65**	**$6,186.30**	**$410.98**	**7.1%**	**$252.66**	**4.3%**
Education & Human Resources	**$832.02**	**$866.00**	**$962.57**	**$130.55**	**15.7%**	**$96.57**	**11.2%**
Major Research Equipment and Facilities Construction	**$200.00**	**$200.76**	**$200.31**	**$0.31**	**0.2%**	**-$0.45**	**-0.2%**
Agency Operations and Award Management	**$305.95**	**$325.00**	**$354.84**	**$48.89**	**16.0%**	**$29.84**	**9.2%**
National Science Board	**$4.25**	**$4.37**	**$4.37**	**$0.12**	**2.8%**	**-**	**-**
Office of Inspector General	**$13.84**	**$14.43**	**$15.16**	**$1.32**	**9.5%**	**$0.73**	**5.1%**
Total, NSF	**$7,131.39**	**$7,344.21**	**$7,723.55**	**$592.16**	**8.3%**	**$379.34**	**5.2%**

Totals may not add due to rounding.

[1] This table reflects the realignment, expected in FY 2015, of the Office of International Science and Engineering (OISE) and Integrative Activities (IA) as separate budget activities. All data are presented in the FY 2015 structure for comparability.

NSF Funding Profile

The Funding Profile presents a high level, agency-wide estimate of proposal pressure, funding rates (or proposal "success"), and award statistics. These indicators are useful in gauging the relative impact of different funding levels.

Statistics for Competitive Awards: Competitive awards encompass the universe of NSF new activity in a given year. Examples include research grants, cooperative agreements, equipment, fellowships, and conferences. The Number of Proposals is based on several factors, including past actual activity, planned competitions, and research trends within the various disciplinary communities. External factors, such as the state of the national economy and other sources of funding, also play a part. The Number of Awards is also based on several factors, including estimated funding and expected proposal pool. The Funding Rate is the number of competitive awards made during a year as a percentage of total proposals competitively reviewed. This indicates the probability of receiving an award when submitting proposals to NSF.

Statistics for Research Grants: Research Grants are a sub-set of competitive awards. The Number of Proposals is based on several factors, including past actual activity, planned competitions, and research trends within the various disciplinary communities. External factors, such as the state of the national economy and other sources of funding, also play a part. The Number of Awards is also based on several factors, including estimated funding and expected proposal pool. Research Grants are grants limited to research projects and exclude other categories of awards such as those for cooperative agreements, equipment, fellowships, and conferences. Annualized Award Size shows the annual level of research grants provided to awardees by dividing the total dollars of each award by the number of years over which it extends. Both the average and the median annualized award size for competitively reviewed awards are shown. Average Duration is the length of awards in years.

NSF Funding Profile

	FY 2014 Actual Estimate	FY 2015 Estimate	FY 2016 Request
Statistics for Competitive Awards			
Number of Proposals	48,000	50,000	51,700
Number of Awards	11,000	11,700	12,000
Funding Rate	23%	23%	23%
Statistics for Research Grants			
Number of Research Grant Proposals	36,900	39,900	41,100
Number of Research Grant Awards	7,700	8,200	8,500
Funding Rate	21%	21%	21%
Median Annualized Award Size	$135,900	$139,800	$140,900
Average Annualized Award Size	$167,800	$174,900	$177,100
Average Duration (years)	3.0	3.0	3.0

Number of People Involved in NSF Activities

NSF estimates that in FY 2016 approximately 356,500 people will be directly involved in NSF programs and activities, receiving salaries, stipends, participant support, and other types of direct involvement. Beyond these figures, NSF programs indirectly impact millions of people, reaching K-12 students and teachers, the general public, and researchers through activities including workshops; informal science activities such as museums, television, videos, and journals; outreach efforts; and dissemination of improved curriculum and teaching methods.

FY 2016 Request
Number of People Involved in NSF Activities

	FY 2014 Actual Estimate	FY 2015 Estimate	FY 2016 Request Estimate
Senior Researchers	40,788	42,500	44,350
Other Professionals	17,151	17,370	18,770
Postdoctoral Associates	5,629	5,720	5,920
Graduate Students	39,806	41,750	43,650
Undergraduate Students	34,080	34,800	37,700
K-12 Teachers	40,079	41,600	46,000
K-12 Students	143,395	147,100	160,100
Total Number of People	**320,928**	**330,840**	**356,490**

Senior Researchers include scientists, mathematicians, engineers, and educators receiving funding through NSF awards. These include both researchers who are principal or co-principal investigators on research and education projects, and researchers working at NSF-supported centers and facilities.

Other Professionals are individuals who may or may not hold a doctoral degree or its equivalent, are considered professionals but are not reported as senior researchers, postdoctoral associates, or students. Examples are technicians, systems experts, etc.

Postdoctoral Associates are individuals who have received Ph.D., M.D., D.Sc., or equivalent and are not faculty members of the performing institution. About 97 percent are supported through funds included in research projects, centers, or facilities awards. Others are recipients of postdoctoral fellowships.

Graduate Students include those compensated from NSF grant funds. Approximately 20 percent receive support through NSF's fellowship and traineeship programs. Others are supported through research assistantships and assist senior researchers or postdoctoral associates in performing research through awards for research projects, centers, or facilities. NSF provides support for approximately 28 percent of the U.S. science and engineering graduate students receiving federal funds and about 5 percent of the science and engineering graduate students in the U.S. overall.[1]

Undergraduate Students include students compensated from NSF grant funds who are enrolled in technical colleges or baccalaureate programs. They may be assisting senior researchers or postdoctoral associates in performing research, or participating in NSF programs aimed at undergraduate students, such as Research Experiences for Undergraduates.

[1] Science and Engineering Indicators 2014: Chapter 2 Higher Education in Science and Engineering, Appendix tables 02-06 and 02-09. www.nsf.gov/statistics/seind14/index.cfm/appendix

K-12 Teachers include teachers at elementary, middle, and secondary schools. These individuals actively participate in intensive professional development experiences in the sciences and mathematics.

K-12 Students are those attending elementary, middle, and secondary schools. They are supported through program components that directly engage students in science and mathematics experiences.

NSF Budget Requests and Appropriations By Account: FY 2000 - FY 2016

(Millions of Current Dollars)

Click here for complete history

	Research & Related Activities (R&RA)		Education & Human Resources (EHR)		Major Research Equipment & Facilities Construction (MREFC)[1]		Agency Operations & Award Management (AOAM)[2]		Office of Inspector General (OIG)		National Science Board (NSB)		NSF, TOTAL	
Fiscal Year	Request	Appropriation	Request	Appropriation	Request	Appropriation	Request	Appropriation	Request	Appropriation	Request	Appropriation	Request	Appropriation
2000	3,004.00	2,972.90	678.00	690.87	85.00	93.50	149.00	149.28	5.45	5.45	-	-	3,921.45	3,912.00
2001	3,540.68	3,356.29	729.01	785.60	138.54	121.33	157.89	161.09	6.28	6.27	-	-	4,572.40	4,430.57
2002	3,326.98	3,612.26	872.41	894.28	96.33	138.80	170.04	171.26	6.76	6.75	-	-	4,472.52	4,823.35
2003	3,783.21	4,069.29	908.08	903.17	126.28	148.54	210.16	189.43	8.06	9.19	-	3.48	5,035.79	5,323.09
2004	4,106.36	4,262.12	938.04	938.98	202.33	154.98	225.70	218.96	8.77	9.94	-	3.88	5,481.20	5,588.86
2005	4,452.31	4,229.98	771.36	841.42	213.27	173.65	294.00	223.45	10.11	10.03	3.95	3.97	5,745.00	5,482.49
2006	4,333.49	4,339.21	737.00	796.69	250.01	190.88	269.00	247.06	11.50	11.35	4.00	3.95	5,605.00	5,589.14
2007	4,665.95	4,654.24	816.22	796.59	240.45	175.61	281.82	248.50	11.86	10.97	3.91	3.97	6,020.21	5,889.87
2008	5,131.69	4,841.73	750.60	765.60	244.74	220.74	285.59	281.79	12.35	11.43	4.03	3.97	6,429.00	6,125.26
2009	*5,593.99*	*5,186.17*	*790.41*	*845.26*	*147.51*	*152.01*	*305.06*	*294.15*	*13.10*	*12.00*	*4.03*	*4.03*	*6,854.10*	*6,493.61*
2009 ARRA	-	*2,500.00*	-	*100.00*	-	*400.00*		-	-	*2.00*		-	-	*3,002.00*
2009 Total	5,593.99	7,686.17	790.41	945.26	147.51	552.01	305.06	294.15	13.10	14.00	4.03	4.03	6,854.10	9,495.61
2010	5,733.24	5,563.92	857.76	872.76	117.29	117.29	318.37	300.00	14.00	14.00	4.34	4.54	7,045.00	6,872.51
2011	6,018.83	5,509.98	892.00	861.03	165.19	117.06	329.19	299.40	14.35	13.97	4.84	4.53	7,424.40	6,805.98
2012	6,253.54	5,689.00	911.20	829.00	224.68	197.06	357.74	299.40	15.00	14.20	4.84	4.44	7,767.00	7,033.10
2013	5,983.28	5,543.72	875.61	833.31	196.17	196.17	299.40	293.60	14.20	13.19	4.44	4.12	7,373.10	6,884.11
2014	6,212.29	5,808.92	880.29	846.50	210.12	200.00	304.29	298.00	14.32	14.20	4.47	4.30	7,625.78	7,171.92
2015	5,807.46	5,933.65	889.75	866.00	200.76	200.76	338.23	325.00	14.43	14.43	4.37	4.37	7,255.00	7,344.21
2016	6,186.30	-	962.57	-	200.31	-	354.84	-	15.16	-	4.37	-	7,723.55	-

Totals may not add due to rounding.

[1] The Major Research Equipment and Facilities Construction (MREFC) account was previously known as Major Research Equipment (MRE) until FY 2002.

[2] The Agency Operations and Award Management (AOAM) account was known as Salaries & Expenses (S&E) until FY 2008.

National Science Foundation
Selected Crosscutting Programs
FY 2016 Budget Request to Congress
(Dollars in Millions)

Selected Cross-Cutting Programs[1]		FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	FY 2016 Request change over: FY 2014 Actual Amount	FY 2014 Actual Percent	FY 2015 Estimate Amount	FY 2015 Estimate Percent
ADVANCE	Research & Related Activities	15.01	13.37	13.37	-1.64	-10.9%	-	-
	Education & Human Resources	1.51	1.53	1.53	0.02	1.2%	-	-
	Total, NSF	**$16.52**	**$14.90**	**$14.90**	**-$1.62**	**-9.8%**	**-**	**-**
Cultivating Cutures for Ethical STEM - (CCE STEM)	Research & Related Activities	2.63	2.54	1.90	-0.73	-27.8%	-0.64	-25.2%
	Education & Human Resources	-	-	-	-	N/A	-	N/A
	Total, NSF	**$2.63**	**$2.54**	**$1.90**	**-$0.73**	**-27.8%**	**-$0.64**	**-25.2%**
Enhancing Access to the Radio Spectrum - EARS	Research & Related Activities	24.10	23.00	21.00	-3.10	-12.9%	-2.00	-8.7%
	Education & Human Resources	-	-	-	-	N/A	-	N/A
	Total, NSF	**$24.10**	**$23.00**	**$21.00**	**-$3.10**	**-12.9%**	**-$2.00**	**-8.7%**
Faculty Early Career Development - CAREER	Research & Related Activities	251.84	222.88	232.49	-19.35	-7.7%	9.61	4.3%
	Education & Human Resources	-	-	-	-	N/A	-	N/A
	Total, NSF	**$251.84**	**$222.88**	**$232.49**	**-$19.35**	**-7.7%**	**$9.61**	**4.3%**
Total, Graduate Fellowships & Traineeships	Research & Related Activities	169.47	200.00	195.38	25.91	15.3%	-4.62	-2.3%
	Education & Human Resources	163.55	194.99	204.13	40.58	24.8%	9.14	4.7%
	Total, NSF	**$333.02**	**$394.99**	**$399.51**	**$66.49**	**20.0%**	**$4.52**	**1.1%**
Graduate Research Fellowship - GRF	*Research & Related Activities*	*150.00*	*166.72*	*168.75*	*18.75*	*12.5%*	*2.03*	*1.2%*
	Education & Human Resources	*149.62*	*166.72*	*168.75*	*19.13*	*12.8%*	*2.03*	*1.2%*
	Total, NSF	***$299.62***	***$333.44***	***$337.50***	***$37.88***	***12.6%***	***$4.06***	***1.2%***
NSF Research Traineeship - NRT[2]	*Research & Related Activities*	*19.47*	*33.28*	*26.63*	*7.16*	*36.8%*	*-6.65*	*-20.0%*
	Education & Human Resources	*13.93*	*28.27*	*35.38*	*21.45*	*154.0%*	*7.11*	*25.2%*
	Total, NSF	***$33.40***	***$61.55***	***$62.01***	***$28.61***	***85.6%***	***$0.46***	***0.7%***
Improving Undergraduate STEM Education - IUSE	Research & Related Activities	7.27	21.40	14.50	7.23	99.4%	-6.90	-32.2%
	Education & Human Resources	74.57	84.00	120.08	45.51	61.0%	36.08	43.0%
	Total, NSF	**$81.84**	**$105.40**	**$134.58**	**$52.74**	**64.4%**	**$29.18**	**27.7%**
Integrated NSF Support Promoting Interdisciplinary Research and Education - INSPIRE	Research & Related Activities	28.68	26.10	26.10	-2.58	-9.0%	-	-
	Education & Human Resources	0.10	1.95	1.95	1.85	1917.4%	-	-
	Total, NSF	**$28.77**	**$28.05**	**$28.05**	**-$0.72**	**-2.5%**	**-**	**-**
Long-Term Ecological Research Sites - LTERs	Research & Related Activities	29.09	27.59	27.95	-1.14	-3.9%	0.36	1.3%
	Education & Human Resources	-	-	-	-	N/A	-	N/A
	Total, NSF	**$29.09**	**$27.59**	**$27.95**	**-$1.14**	**-3.9%**	**$0.36**	**1.3%**
Research Experiences for Undergraduates - REU - Sites Only	Research & Related Activities	60.30	53.31	54.03	-6.27	-10.4%	0.72	1.4%
	Education & Human Resources	-	-	-	-	N/A	-	N/A
	Total, NSF	**$60.30**	**$53.31**	**$54.03**	**-$6.27**	**-10.4%**	**$0.72**	**1.4%**
Research Experiences for Undergraduates - REU - Supplements Only	Research & Related Activities	25.94	19.89	23.57	-2.37	-9.1%	3.68	18.5%
	Education & Human Resources	-	-	-	-	N/A	-	N/A
	Total, NSF	**$25.94**	**$19.89**	**$23.57**	**-$2.37**	**-9.1%**	**$3.68**	**18.5%**
Total, Research Experiences for Undergraduates - REU	Research & Related Activities	86.24	73.20	77.60	-8.64	-10.0%	4.40	6.0%
	Education & Human Resources	-	-	-	-	N/A	-	N/A
	Total, NSF	**$86.24**	**$73.20**	**$77.60**	**-$8.64**	**-10.0%**	**$4.40**	**6.0%**
Research in Undergraduate Institutions - RUI	Research & Related Activities	41.42	39.60	39.15	-2.27	-5.5%	-0.45	-1.1%
	Education & Human Resources	-	-	-	-	N/A	-	N/A
	Total, NSF	**$41.42**	**$39.60**	**$39.15**	**-$2.27**	**-5.5%**	**-$0.45**	**-1.1%**

Totals may not add due to rounding.

[1] For descriptions of these programs, see the NSF-Wide Investments chapter.

[2] Outyear commitments to the Integrative Graduate Education and Research Traineeship (IGERT) program are included in the NRT line and total $32.81 million in FY 2014, $12.12 million in FY 2015, and $10.33 million in FY 2016.

National Science Foundation
NSTC Crosscuts Summary
FY 2016 Request to Congress
(Dollars in Millions)

	National Nanotechnology Initiative (NNI)						
				FY 2016 Request change over:			
	FY 2014	FY 2015	FY 2016	FY 2014 Actual		FY 2015 Estimate	
	Actual	Estimate	Request	Amount	Percent	Amount	Percent
BIO	$50.28	$48.80	$48.80	-$1.48	-2.9%	-	-
CISE	13.23	13.66	14.14	0.91	6.9%	0.48	3.5%
ENG	204.76	166.00	168.50	-36.26	-17.7%	2.50	1.5%
GEO	0.30	0.30	0.30	-	-	-	-
MPS	191.70	180.62	180.62	-11.08	-5.8%	-	-
SBE	1.67	1.40	1.40	-0.27	-16.2%	-	-
OISE	0.10	0.10	0.10	-	-	-	-
IA	-	-	-	-	N/A	-	N/A
R&RA	**$462.04**	**$410.88**	**$413.86**	**-$48.18**	**-10.4%**	**$2.98**	**0.7%**
EHR	**$2.50**	**$2.50**	**$2.50**	**-**	**-**	**-**	**-**
NSF Total	**$464.54**	**$413.38**	**$416.36**	**-$48.18**	**-10.4%**	**$2.98**	**0.7%**

	Networking & Information Technology R&D (NITRD)						
				FY 2016 Request change over:			
	FY 2014	FY 2015	FY 2016	FY 2014 Actual		FY 2015 Estimate	
	Actual	Estimate	Request	Amount	Percent	Amount	Percent
BIO	$99.00	$99.00	$99.00	-	-	-	-
CISE	892.60	921.73	954.41	61.81	6.9%	32.68	3.5%
ENG	19.80	18.75	18.75	-1.05	-5.3%	-	-
GEO	24.00	24.00	23.00	-1.00	-4.2%	-1.00	-4.2%
MPS	78.72	81.80	81.10	2.38	3.0%	-0.70	-0.9%
SBE	28.23	31.20	31.20	2.97	10.5%	-	-
OISE	-	-	-	-	N/A	-	N/A
IA	-	-	-	-	N/A	-	N/A
R&RA	**$1,142.35**	**$1,176.48**	**$1,207.46**	**$65.11**	**5.7%**	**$30.98**	**2.6%**
EHR	**$9.50**	**$9.50**	**$9.50**	**-**	**-**	**-**	**-**
NSF Total	**$1,151.85**	**$1,185.98**	**$1,216.96**	**$65.11**	**5.7%**	**$30.98**	**2.6%**

	U.S. Global Change Research Program (USGCRP)						
				FY 2016 Request change over:			
	FY 2014	FY 2015	FY 2016	FY 2014 Actual		FY 2015 Estimate	
	Actual	Estimate	Request	Amount	Percent	Amount	Percent
BIO	$91.00	$104.00	$110.04	$19.04	20.9%	$6.04	5.8%
CISE	-	-	-	-	N/A	-	N/A
ENG	-	-	-	-	N/A	-	N/A
GEO	195.15	202.09	209.09	13.94	7.1%	7.00	3.5%
MPS	14.37	6.50	3.50	-10.87	-75.6%	-3.00	-46.2%
SBE	19.73	17.98	17.98	-1.75	-8.9%	-	-
OISE	-	-	-	-	N/A	-	N/A
IA	-	-	-	-	N/A	-	N/A
R&RA	**$320.25**	**$330.57**	**$340.61**	**$20.36**	**6.4%**	**$10.04**	**3.0%**
EHR	**-**	**-**	**-**	**-**	**N/A**	**-**	**N/A**
NSF Total	**$320.25**	**$330.57**	**$340.61**	**$20.36**	**6.4%**	**$10.04**	**3.0%**

Totals may not add due to rounding.

National Science Foundation
Homeland Security Activities Summary
FY 2016 Request to Congress
(Dollars in Millions)

	BIO	CISE	ENG	GEO	MPS	SBE	IA	R&RA	EHR	AOAM	Total, NSF
FY 2014 Actual	**$15.00**	**$203.30**	**$155.90**	**$3.31**	**$8.36**	**$10.03**	**$2.57**	**$398.47**	**$45.26**	**$1.76**	**$445.49**
Protecting Critical Infrastructure & Key Assets	**-**	**$203.30**	**$155.90**	**$3.31**	**$6.65**	**$10.03**	**$2.57**	**$381.76**	**$45.26**	**$1.76**	**$428.78**
Antarctic Physical Security	-	-	-	0.30	-	-	-	**$0.30**	-	-	**$0.30**
Counterterrorism	-	27.00	-	-	-	-	-	**$27.00**	-	-	**$27.00**
Cybersecurity	-	147.00	4.25	-	2.00	5.03	-	**$158.28**	-	-	**$158.28**
Electronic Commerce	-	4.50	3.35	-	-	-	-	**$7.85**	-	-	**$7.85**
Emergency Planning & Response	-	24.80	25.30	-	4.00	-	-	**$54.10**	-	-	**$54.10**
Energy Supply Assurance	-	-	28.00	-	-	-	-	**$28.00**	-	-	**$28.00**
IT Security	-	-	-	3.01	-	-	2.57	**$5.58**	0.39	1.76	**$7.73**
Resilient Infrastructure	-	-	95.00	-	0.65	5.00	-	**$100.65**	-	-	**$100.65**
Scholarship for Service/Cybercorps	-	-	-	-	-	-	-	**-**	44.87	-	**$44.87**
Defending Against Catastrophic Threats	**$15.00**	**-**	**-**	**-**	**$1.71**	**-**	**-**	**$16.71**	**-**	**-**	**$16.71**
Research to Combat Bioterrorism - Microbial Genomics, Analysis & Modeling	15.00	-	-	-	1.71	-	-	**$16.71**	-	-	**$16.71**
FY 2015 Estimate	**$15.00**	**$203.30**	**$151.67**	**$3.31**	**$3.73**	**$11.00**	**$2.56**	**$390.57**	**$45.42**	**$2.79**	**$438.78**
Protecting Critical Infrastructure & Key Assets	**-**	**$203.30**	**$151.67**	**$3.31**	**$3.73**	**$11.00**	**$2.56**	**$375.57**	**$45.42**	**$2.79**	**$423.78**
Antarctic Physical Security	-	-	-	0.30	-	-	-	**$0.30**	-	-	**$0.30**
Counterterrorism	-	27.00	-	-	-	-	-	**$27.00**	-	-	**$27.00**
Cybersecurity	-	147.00	5.11	-	2.03	6.00	-	**$160.14**	-	-	**$160.14**
Electronic Commerce	-	4.50	3.00	-	-	-	-	**$7.50**	-	-	**$7.50**
Emergency Planning & Response	-	24.80	24.50	-	1.00	-	-	**$50.30**	-	-	**$50.30**
Energy Supply Assurance	-	-	26.00	-	-	-	-	**$26.00**	-	-	**$26.00**
IT Security	-	-	-	3.01	-	-	2.56	**$5.57**	0.42	2.79	**$8.78**
Resilient Infrastructure	-	-	93.06	-	0.70	5.00	-	**$98.76**	-	-	**$98.76**
Scholarship for Service/Cybercorps	-	-	-	-	-	-	-	**-**	45.00	-	**$45.00**
Defending Against Catastrophic Threats	**$15.00**	**-**	**-**	**-**	**-**	**-**	**-**	**$15.00**	**-**	**-**	**$15.00**
Research to Combat Bioterrorism - Microbial Genomics, Analysis & Modeling	15.00	-	-	-	-	-	-	**$15.00**	-	-	**$15.00**
Delta from FY 2015 Estimate	**-**	**$0.50**	**$1.88**	**-**	**-$0.03**	**-**	**-**	**$2.35**	**-**	**$0.24**	**$2.59**
Protecting Critical Infrastructure & Key Assets	**-**	**$0.50**	**$1.88**	**-**	**-$0.03**	**-**	**-**	**$2.35**	**-**	**$0.24**	**$2.59**
Antarctic Physical Security	-	-	-	-	-	-	-	**-**	-	-	**-**
Counterterrorism	-	-	-	-	-	-	-	**-**	-	-	**-**
Cybersecurity	-	0.50	-0.06	-	-0.03	-	-	**$0.41**	-	-	**$0.41**
Electronic Commerce	-	-	-	-	-	-	-	**-**	-	-	**-**
Emergency Planning & Response	-	-	-	-	-	-	-	**-**	-	-	**-**
Energy Supply Assurance	-	-	-	-	-	-	-	**-**	-	-	**-**
IT Security	-	-	-	-	-	-	-	**-**	-	0.24	**$0.24**
Resilient Infrastructure	-	-	1.94	-	-	-	-	**$1.94**	-	-	**$1.94**
Scholarship for Service/Cybercorps	-	-	-	-	-	-	-	**-**	-	-	**-**
Defending Against Catastrophic Threats	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Research to Combat Bioterrorism - Microbial Genomics, Analysis & Modeling	-	-	-	-	-	-	-	**-**			**-**
FY 2016 Request	**$15.00**	**$203.80**	**$153.55**	**$3.31**	**$3.70**	**$11.00**	**$2.56**	**$392.92**	**$45.42**	**$3.03**	**$441.37**
Protecting Critical Infrastructure & Key Assets	**-**	**$203.80**	**$153.55**	**$3.31**	**$3.70**	**$11.00**	**$2.56**	**$377.92**	**$45.42**	**$3.03**	**$426.37**
Antarctic Physical Security	-	-	-	0.30	-	-	-	**$0.30**	-	-	**$0.30**
Counterterrorism	-	27.00	-	-	-	-	-	**$27.00**	-	-	**$27.00**
Cybersecurity	-	147.50	5.05	-	2.00	6.00	-	**$160.55**	-	-	**$160.55**
Electronic Commerce	-	4.50	3.00	-	-	-	-	**$7.50**	-	-	**$7.50**
Emergency Planning & Response	-	24.80	24.50	-	1.00	-	-	**$50.30**	-	-	**$50.30**
Energy Supply Assurance	-	-	26.00	-	-	-	-	**$26.00**	-	-	**$26.00**
IT Security	-	-	-	3.01	-	-	2.56	**$5.57**	0.42	3.03	**$9.02**
Resilient Infrastructure	-	-	95.00	-	0.70	5.00	-	**$100.70**	-	-	**$100.70**
Scholarship for Service/Cybercorps	-	-	-	-	-	-	-	**-**	45.00	-	**$45.00**
Defending Against Catastrophic Threats	**$15.00**	**-**	**-**	**-**	**-**	**-**	**-**	**$15.00**	**-**	**-**	**$15.00**
Research to Combat Bioterrorism - Microbial Genomics, Analysis & Modeling	15.00	-	-	-	-	-	-	**$15.00**	-	-	**$15.00**

Totals may not add due to rounding.

National Science Foundation
Programs to Broaden Participation
FY 2016 Request to Congress

(Dollars in Millions)

Group/Program	Amount of Funding Captured	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	FY 2016 Request Change Over FY 2015 Estimate Amount	FY 2016 Request Change Over FY 2015 Estimate Percent
Focused Programs		**$165.78**	**$169.12**	**$183.84**	**$14.72**	**8.7%**
ADVANCE	100%	16.52	14.90	14.90	-	-
Alliances for Graduate Education & the Professoriate (AGEP)	100%	8.18	8.00	7.84	-0.16	-2.0%
AGEP Graduate Research Supplements	100%	1.77	0.15	0.60	0.45	300.0%
Broadening Participation in Biology Fellowships	100%	2.50	2.50	2.50	-	-
Broadening Participation in Engineering (BPE)	100%	4.99	6.00	7.00	1.00	16.7%
Career-Life Balance (CLB)	100%	2.10	1.00	1.00	-	-
Centers of Research Excellence in Science & Technology (CREST)	100%	22.92	24.00	22.98	-1.02	-4.3%
Engineering Graduate Research Diversity Supplements (GRDS)[1]	100%	0.04	-	-	-	N/A
Excellence Awards in Science & Engineering (EASE)[2]	100%	3.05	5.82	5.82	-	-
Geosciences Postdoctoral Fellowships	100%	5.10	3.82	2.71	-1.11	-29.1%
Historically Black Colleges & Universities Undergraduate Program (HBCU-UP)	100%	31.76	32.00	31.94	-0.06	-0.2%
Inclusion across the Nation of Communities of Learners that have been Underrepresented for Diversity in Engineering and Science (NSF INCLUDES)	100%	-	-	15.00	15.00	N/A
Louis Stokes Alliances for Minority Participation (LSAMP)	100%	45.51	46.00	45.62	-0.38	-0.8%
Partnerships for Research & Education in Materials (PREM)	100%	3.54	6.43	6.43	-	-
Partnerships in Astronomy & Astrophysics Research Education (PAARE)	100%	1.24	1.00	2.00	1.00	100.0%
Pre-Engineering Education Collaboratives (PEEC)	100%	1.00	1.00	1.00	-	-
SBE Postdoctoral Research Fellowships-Broadening Participation	100%	1.10	1.50	1.50	-	-
Tribal Colleges & Universities Program (TCUP)	100%	13.47	13.50	13.50	-	-
SBE Science of Broadening Participation	100%	1.00	1.50	1.50	-	-
Emphasis Programs		**$452.21**	**$432.61**	**$433.39**	**$0.78**	**0.2%**
Advancing Informal STEM Learning (AISL)	55%	30.19	30.28	33.04	2.75	9.1%
Centers for Ocean Science Education Excellence (COSEE)[3]	100%	0.76	-	-	-	N/A
Discovery Research K-12 (DR-K12)	64%	58.68	53.24	58.39	5.16	9.7%
Graduate Research Fellowship (GRF)	60%	179.77	200.06	202.50	2.44	1.2%
Innovative Technology Experiences for Teachers & Students (ITEST)[4]	72%	26.80	18.00	18.00	-	-
International Research Experiences for Students (IRES)	55%	3.45	1.23	1.23	-	-
Noyce Scholarships	57%	35.67	34.70	34.70	-	-
NSF Scholarships in STEM (S-STEM)[4]	60%	55.03	44.78	44.78	-	-
Ocean Sciences Research Initiation Grants (OCE-RIG)[5]	89%	0.36	-	-	-	N/A
Science of Learning Centers (SLCs)[6]	90%	17.31	6.28	-	-6.28	-100.0%
STEM + Computing Partnerships (STEM + C Partnerships)	63%	44.19	44.04	40.75	-3.29	-7.5%
Total, Focused and Emphasis Programs		**$618.00**	**$601.73**	**$617.23**	**$15.50**	**2.6%**

(Dollars in Millions)

Group/Program	Amount of Funding Captured	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	FY 2016 Request Change Over FY 2015 Estimate Amount	FY 2016 Request Change Over FY 2015 Estimate Percent
Total, Focused and Emphasis Programs		**$618.00**	**$601.73**	**$617.23**	**$15.50**	**2.6%**
Geographic Diversity Program		**$158.19**	**$159.69**	**$169.99**	**$10.30**	**6.4%**
EPSCoR	100%	158.19	159.69	169.99	10.30	6.4%
Total, NSF		**$776.19**	**$761.42**	**$787.22**	**$25.80**	**3.4%**

Totals may not add due to rounding.

[1] Support for GRDS is suspended beginning in FY 2015 pending an internal review.

[2] The Excellence Awards in Science and Engineering (EASE) program is comprised of both Presidential Awards for Excellence in Science, Math and Engineering Mentoring (PAESMEM) and Presidential Awards for Excellence in Mathematics and Science Teaching (PAEMST).

[3] The COSEE program terminated in FY 2014.

[4] NSF Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM) and Innovative Technology Experiences for Students and Teachers (ITEST) are H1B Visa funded programs.

[5] In FY 2015, OCE's Research Initiation Grants program is being discontinued as its companion postdoctoral fellowship program is ending.

[6] The Science of Learning Centers (SLC) program terminates in FY 2015. FY 2014 and FY 2015 support represents outyear funding commitments for sunsetting centers.

Focused Programs have broadening participation as an explicit goal of the program and are included at 100 percent of their funding.

Emphasis Programs have broadening participation as one of several emphases but broadening participation is not an explicit goal of the program. These programs are included at a percentage of their funding level. The percentage used equals the 3-year average percentage of the programs' award portfolio that meets one the following criteria:

- At least 50 percent of the principle investigators are from an underrepresented group;
- The award was to a Minority Serving Institution (MSI); or
- At least 50 percent of the students or postdocs supported by the grant reported themselves as members of an underrepresented group on project reports.

Geographic Diversity Program, EPSCoR, has geographic diversity as an explicit goal of the program and is included at 100 percent of its funding.

National Science Foundation
CoSTEM Inventory and Postdoctoral Fellowship Programs By Level of Education
FY 2016 Request to Congress
(Dollars in Millions)

Level of Education	Program Name	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	FY 2016 Request Change Over FY 2015 Estimate Amount	Percent
Minority-Serving Institutions		**$45.23**	**$45.50**	**$45.50**	**-**	**-**
UG	Historically Black Colleges & Universities Undergraduate Program (HBCU-UP)	31.76	32.00	32.00	-	-
UG	Tribal Colleges & Universities Program (TCUP)	13.47	13.50	13.50	-	-
Fellowships & Scholarships		**$549.07**	**$583.97**	**$582.80**	**-$1.17**	**-0.2%**
G	Cybercorps®: Scholarships for Service (SfS)	44.87	45.00	45.00	-	-
G	East Asia & Pacific Summer Institutes for US Grad Students (EAPSI)	0.94	2.40	2.40	-	-
G	Enhancing the Math Sciences Workforce in the 21st Century (EMSW21)	15.47	5.69	-	-5.69	-100.0%
G	Graduate Research Fellowship (GRF)	299.62	333.44	337.50	4.06	1.2%
G	NSF Research Traineeship (NRT)[1]	33.40	61.55	62.01	0.46	0.7%
UG	NSF Scholarships in STEM (S-STEM) (H-1B)	92.18	75.00	75.00	-	-
UG	Robert Noyce Scholarship (Noyce) Program	62.59	60.89	60.89	-	-
Other Grant Programs[2]		**$557.69**	**$546.01**	**$602.61**	**$56.60**	**10.4%**
K-12	Discovery Research K-12 (DR-K12)	92.38	83.81	91.93	8.12	9.7%
K-12	Innovative Technology Experiences for Teachers & Students (ITEST)(H1-B)	37.23	25.00	25.00	-	-
K-12	STEM + Computing Partnerships (STEM + C Partnerships)	69.82	69.58	64.38	-5.20	-7.5%
UG	Advanced Technological Education (ATE)	63.61	66.00	66.00	-	-
UG	Improving Undergraduate STEM Education (IUSE)	81.84	105.40	134.58	29.18	27.7%
UG	International Research Experiences for Students (IRES)	6.29	2.25	2.25	-	-
UG	Louis Stokes Alliances for Minority Participation (LSAMP)	45.51	46.00	46.00	-	-
UG	Res Exper for Undergrads (REU)-Sites & Supplements	86.24	73.20	77.60	4.40	6.0%
UG	Research Experiences for Teachers (RET) in Engineering and Computer Science	7.95	5.95	6.05	0.10	1.7%
G	Alliances for Graduate Education & the Professoriate (AGEP)	8.18	8.00	8.00	-	-
O&I	Advancing Informal STEM Learning (AISL)	54.84	55.00	60.00	5.00	9.1%
O&I	Centers for Ocean Science Education Excellence (COSEE)	0.76	-	-	-	N/A
O&I	Excellence Awards in Science & Engineering (EASE)	3.05	5.82	5.82	-	-
O&I	NSF INCLUDES	-	-	15.00	15.00	N/A
Subtotal, Above Categories (CoSTEM Inventory Programs)		**$1,151.99**	**$1,175.48**	**$1,230.91**	**$55.43**	**4.7%**
G	**NSF Postdoctoral Programs**	**$28.15**	**$24.62**	**$23.61**	**-$1.01**	-4.1%
	Astronomy & Astrophysics Postdoctoral Fellowships (AAPF)	2.05	2.30	2.40	0.10	4.3%
	Geosciences Postdoctoral Fellowships	5.10	3.82	2.71	-1.11	-29.1%
	International Research Fellowship Program	3.05	3.60	3.60	-	-
	Mathematical Sciences Postdoctoral Research Fellowships (MSPRF)	6.45	4.10	4.10	-	-
	Postdoctoral Research Fellowships in Biology (PRFB)	8.65	7.80	7.80	-	-
	SBE Minority Postdoctoral Fellowships	0.06	-	-	-	N/A
	SPRF-Broadening Participation	1.10	1.50	1.50	-	-
	SPRF-Interdisciplinary Research in Behavioral & Social Sciences	1.69	1.50	1.50	-	-
K-12 STEM Education Programs (K-12) Subtotal		**$199.42**	**$178.39**	**$181.31**	**$2.92**	**1.6%**
Undergraduate STEM Education Programs (UG) Subtotal		**$491.45**	**$480.19**	**$513.87**	**$33.68**	**7.0%**
Graduate and Professional STEM Education Programs (G) Subtotal		**$430.62**	**$480.70**	**$478.52**	**-$2.18**	**-0.5%**
Outreach and/or Informal STEM Education Programs (O&I) Subtotal		**$58.64**	**$60.82**	**$80.82**	**$20.00**	**32.9%**
Total, NSF STEM Education		**$1,180.14**	**$1,200.10**	**$1,254.52**	**$54.42**	**4.5%**

Totals may not add due to rounding.

[1] Outyear commitments for Integrative Graduate Education and Research Traineeship (IGERT) are included in the NRT funding line and are $32.81 million in FY 2014, $12.12 million in FY 2015, and $10.33 million in FY 2016.

[2] For comparability, Research on Education and Learning (REAL) is not included in FY 2014 because it was consolidated into EHR Core Research (ECR) in FY 2015 and FY 2016. ECR is not included in the CoSTEM Inventory. FY 2014 Actual for REAL is $48.38 million.

National Science Foundation
Education and Human Resources Funding by Division and Program
FY 2016 Request to Congress
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	FY 2016 Request Change Over FY 2015 Estimate Amount	Percent
Division of Research on Learning in Formal and Informal Settings (DRL)	**$230.13**	**$221.52**	**$253.08**	**$31.56**	**14.2%**
Learning and Learning Environments	**25.39**	**25.63**	**49.27**	**23.64**	**92.2%**
EHR Core Research (ECR): STEM Learning	25.39	25.63	49.27	23.64	92.2%
Broadening Participation & Institutional Capacity	**147.22**	**138.81**	**151.93**	**13.12**	**9.5%**
Advancing Informal STEM Learning (AISL)	54.84	55.00	60.00	5.00	9.1%
Discovery Research K-12 (DRK-12)	92.38	83.81	91.93	8.12	N/A
STEM Professional Workforce	**57.52**	**57.08**	**51.88**	**-5.20**	**-9.1%**
INSPIRE	0.10	-	-	-	-
Science, Technology, Engineering, and Mathematics + Computing (STEM + C) Partnerships	57.43	57.08	51.88	-5.20	-9.1%
Division of Graduate Education (DGE)	**$245.58**	**$273.41**	**$295.64**	**$22.23**	**8.1%**
Learning and Learning Environments	**21.26**	**15.50**	**21.47**	**5.97**	**38.5%**
Project and Program Evaluation (PPE)	21.26	15.50	21.47	5.97	38.5%
STEM Professional Workforce	**224.31**	**257.91**	**274.17**	**16.26**	**6.3%**
EHR Core Research (ECR): STEM Professional Workforce Preparation	15.89	15.97	20.09	4.12	25.8%
Cybercorps®: Scholarships for Service (SFS)	44.87	45.00	45.00	-	-
NSF INCLUDES	-	-	3.00	3.00	N/A
INSPIRE	-	1.95	1.95	-	-
Graduate Research Fellowship (GRF)	149.62	166.72	168.75	2.03	1.2%
NSF Research Traineeship (NRT)[1]	13.93	28.27	35.38	7.11	25.2%
Division of Human Resource Development (HRD)	**$139.21**	**$143.73**	**$145.59**	**$1.86**	**1.3%**
Learning and Learning Environments	**54.92**	**55.03**	**55.03**	**-**	**-**
ADVANCE	1.51	1.53	1.53	-	-
Alliances for Graduate Education and the Professoriate (AGEP)	8.18	8.00	8.00	-	-
Historically Black Colleges and Universities Undergraduate Program (HBCU-UP)	31.76	32.00	32.00	-	-
Tribal Colleges and Universities Program (TCUP)	13.47	13.50	13.50	-	-
Broadening Participation & Institutional Capacity	**58.33**	**58.88**	**60.74**	**1.86**	**3.2%**
EHR Core Research (ECR): Broadening Participation and Institutional Capacity in STEM	12.82	12.88	14.74	1.86	14.4%
Louis Stokes Alliances for Minority Participation (LSAMP)	45.51	46.00	46.00	-	-
STEM Professional Workforce	**25.97**	**29.82**	**29.82**	**-**	**-**
Centers for Research Excellence in Science and Technology (CREST)	22.92	24.00	24.00	-	-
Excellence Awards in Science and Engineering (EASE)	3.05	5.82	5.82	-	-
Division of Undergraduate Education (DUE)	**$217.10**	**$227.34**	**$268.26**	**$40.92**	**18.0%**
Learning and Learning Environments	**90.54**	**100.10**	**139.82**	**39.72**	**39.7%**
EHR Core Research (ECR): STEM Learning Environments	15.97	16.10	19.74	3.64	22.6%
Improving Undergraduate STEM Education (IUSE)	74.57	84.00	120.08	36.08	43.0%
STEM Professional Workforce	**126.55**	**127.24**	**128.44**	**1.20**	**0.9%**
Advanced Technological Education (ATE)	63.61	66.00	66.00	-	-
NSF Innovation Corps (I-Corps™)	0.35	0.35	1.55	1.20	342.9%
Robert Noyce Teacher Scholarship Program (NOYCE)	62.59	60.89	60.89	-	-
Total, EHR	**$832.02**	**$866.00**	**$962.57**	**$96.57**	**11.2%**
Total, Learning and Learning Environments	$192.12	$196.26	$265.59	$69.33	35.3%
Total, Broadening Participation & Institutional Capacity	$205.55	$197.69	$212.67	$14.98	7.6%
Total, STEM Professional Workforce	$434.35	$472.05	$484.31	$12.26	2.6%

Totals may not add due to rounding.

For comparability, Research on Education and Learning (REAL) is included on the EHR Core Research (ECR) lines for FY 2014 because the program was consolidated into ECR in FY 2015 and FY 2016. The FY 2014 Actual for REAL is $48.38 million.

[1] Outyear commitments for Integrative Graduate Education and Research Traineeship (IGERT) are included in the NRT funding line and are $13.34 million in FY 2014, $4.40 million in FY 2015, and $2.85 million in FY 2016.

National Science Foundation
Research Infrastructure (RI) Funding, by Account and Activity
FY 2016 Request to Congress

(Dollars in Millions)

							FY 2016 Request RI over:			
		FY 2014		FY 2015		FY 2016	FY 2014 Actual RI		FY 2015 Estimate RI	
	FY 2014 Actual	Actual RI Funding	**FY 2015 Estimate**	Estimate RI Funding	**FY 2016 Request**	Request RI Funding	**Amount**	**Percent**	**Amount**	**Percent**
BIO	**$720.84**	$120.57	**$731.03**	$140.24	**$747.92**	$149.17	$28.60	23.7%	$8.93	6.4%
CISE	**892.60**	167.36	**921.73**	157.90	**954.41**	167.90	0.54	0.3%	10.00	6.3%
ENG	**833.12**	33.86	**892.31**	27.83	**949.22**	28.33	-5.53	-16.3%	0.50	1.8%
GEO	**1,321.32**	694.00	**1,304.39**	686.41	**1,365.41**	709.04	15.04	2.2%	22.63	3.3%
MPS	**1,267.86**	338.58	**1,336.72**	324.64	**1,366.23**	348.72	10.14	3.0%	24.09	7.4%
SBE	**256.84**	51.42	**272.20**	61.31	**291.46**	64.89	13.47	26.2%	3.58	5.8%
OISE	**48.31**	0.10	**48.52**	0.10	**51.02**	0.10	-	-	-	-
IA	**433.12**	94.47	**425.34**	79.74	**459.15**	79.74	-14.73	-15.6%	-	-
U.S. Arctic Research Commission	**1.30**	-	**1.41**	-	**1.48**	-	-	N/A	-	N/A
Research and Related Activities	**$5,775.32**	$1,500.36	**$5,933.65**	$1,478.16	**$6,186.30**	$1,547.89	$47.53	3.2%	$69.73	4.7%
Education and Human Resources	**$832.02**	-	**$866.00**	-	**$962.57**	-	-	N/A	-	N/A
Major Research Equipment and Facilities Construction	**$200.00**	$200.00	**$200.76**	$200.76	**$200.31**	$200.31	$0.31	0.2%	-$0.45	-0.2%
Agency Operations and Award Management	**$305.95**	-	**$325.00**	-	**$354.84**	-	-	N/A	-	N/A
National Science Board	**$4.25**	-	**$4.37**	-	**$4.37**	-	-	N/A	-	N/A
Office of Inspector General	**$13.84**	-	**$14.43**	-	**$15.16**	-	-	N/A	-	N/A
Total, National Science Foundation	**$7,131.39**	$1,700.36	**$7,344.21**	$1,678.92	**$7,723.55**	$1,748.20	**$47.84**	**2.8%**	**$69.28**	**4.1%**

Totals may not add due to rounding.

National Science Foundation
Research Infrastructure Summary
FY 2016 Request to Congress

(Dollars in Millions)

				FY 2016 Request change over:			
				FY 2014 Actual		FY 2015 Estimate	
	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Amount	Percent	Amount	Percent
Facilities	**$978.61**	**$973.76**	**$1,006.26**	**$27.65**	**2.8%**	**$32.50**	**3.3%**
Academic Research Fleet	84.86	87.00	88.00	3.14	3.7%	1.00	1.1%
ARF-Academic Research Fleet, Ship Ops & Upgrades	*83.00*	*85.00*	*85.00*	*2.00*	*2.4%*	-	-
ARF-Regional Class Research Vessels (RCRV)[1]	*1.86*	*2.00*	*3.00*	*1.14*	*61.0%*	*1.00*	*50.0%*
Arecibo Observatory	8.00	8.00	8.20	0.20	2.5%	0.20	2.5%
AST Portfolio Review Implementation	0.85	7.00	7.00	6.15	720.5%	-	-
Cornell High Energy Synchrotron Source (CHESS)	20.04	20.00	20.00	-0.04	-0.2%	-	-
Gemini Observatory	19.58	20.61	19.77	0.19	1.0%	-0.84	-4.1%
Geodesy Advancing Geosciences and EarthScope (GAGE)	11.58	11.58	12.33	0.75	6.5%	0.75	6.5%
George E. Brown Jr. Network for Earthquake Engineering Simulation (NEES)[2]	18.14	-	-	-18.14	-100.0%	-	N/A
IceCube Neutrino Observatory (IceCube)	6.90	6.90	6.90	-	-	-	-
International Ocean Discovery Program (IODP)	50.00	48.00	48.00	-2.00	-4.0%	-	-
Large Hadron Collider (LHC)	17.37	18.00	18.00	0.63	3.6%	-	-
Laser-Interferometer Gravity-wave Observatory (LIGO)	36.43	39.43	39.43	3.00	8.2%	-	-
National High-Magnetic Field Laboratory (NHMFL)	42.26	24.04	34.66	-7.60	-18.0%	10.62	44.2%
National Nanotechnology Coordinated Infrastructure (NNCI)[3]	-	15.46	15.46	15.46	N/A	-	-
National Nanotechnology Infrastructure Network (NNIN)[3]	15.30	-	-	-15.30	-100.0%	-	N/A
National Solar Observatory (NSO)	8.00	8.00	9.50	1.50	18.8%	1.50	18.8%
National Superconducting Cyclotron Laboratory (NSCL)(MSU Cyclotron)	22.50	22.50	22.50	-	-	-	-
Natural Hazards Engineering Research Infrastructure (NHERI)[2]	-	12.00	12.50	12.50	N/A	0.50	4.2%
Ocean Observatories Initiative (OOI)	49.30	55.00	55.00	5.70	11.6%	-	-
Other Facilities[4]	2.66	2.66	2.66	-	-	-	-
Polar Facilities and Logistics	310.00	295.47	302.90	-7.10	-2.3%	7.43	2.5%
Seismological Facilities for Advancement of Geoscience & EarthScope (SAGE)	24.35	24.35	25.10	0.75	3.1%	0.75	3.1%
Other Facilities Investments							
Major Research Equipment and Facilities Construction[5]	230.48	245.76	255.35	24.87	10.8%	9.59	3.9%
Facilities Pre-Construction Planning[6]	-	2.00	3.00	3.00	N/A	1.00	50.0%
Federally Funded R&D Centers	**$204.40**	**$211.75**	**$207.57**	**$3.17**	**1.6%**	**-$4.18**	**-2.0%**
National Center for Atmospheric Research (NCAR)	96.60	98.20	99.00	2.40	2.5%	0.80	0.8%
National Optical Astronomy Observatories (NOAO)	25.50	25.50	21.75	-3.75	-14.7%	-3.75	-14.7%
National Radio Astronomy Observatories (NRAO)[7]	77.41	83.31	82.08	4.67	6.0%	-1.23	-1.5%
Science & Technology Policy Institute (STPI)	4.89	4.74	4.74	-0.15	-3.1%	-	-
Other Research Instrumentation and Infrastructure	**$517.36**	**$493.41**	**$534.37**	**$17.01**	**3.3%**	**$40.96**	**8.3%**
Major Research Instrumentation (MRI)	89.59	75.00	75.00	-14.59	-16.3%	-	-
Mid-Scale Research Infrastructure	-	-	52.99	52.99	N/A	52.99	N/A
National Center for Science & Engineering Statistics (NCSES)	34.61	45.17	48.75	14.14	40.9%	3.58	7.9%
NCSES Science of Science and Innovation Policy (SciSIP) Activities	4.46	4.95	4.95	0.50	11.1%	-	-
Networking and Computational Resources Infrastructure and Services	127.53	113.80	123.80	-3.73	-2.9%	10.00	8.8%
Polar Environment, Health, and Safety (PEHS)	7.07	6.24	6.50	-0.57	-8.0%	0.26	4.2%
Research Resources[8]	252.66	246.50	220.63	-32.03	-12.7%	-25.87	-10.5%
Research Resources – Public Access Initiative	1.45	1.75	1.75	0.30	20.7%	-	-
RESEARCH INFRASTRUCTURE TOTAL	**$1,700.36**	**$1,678.92**	**$1,748.20**	**$47.84**	**2.8%**	**$69.28**	**4.1%**

[1] Regional Class Research Vessels are a Pre-construction Planning project for potential MREFC funding. This funding is shown here (Academic Resesarch Fleet) and is not included under Pre-construction Planning.

[2] Funding for the George E. Brown Jr. Network for Earthquake Engineering (NEES) concluded in FY 2014. Natural Hazards Engineering Research Infrastructure (NHERI) is the successor program to NEES, beginning in FY 2015.

[3] Funding for the National Nanotechnology Infrastructure Network (NNIN) concluded in FY 2014. National Nanotechnology Coordinated Infrastructure (NNCI) is the successor program, beginning in FY 2015.

[4] Other Facilities includes support for other materials research facilities.

[5] Funding levels for MREFC Projects in this table include support for: a) concept and development associated with ongoing and requested MREFC projects provided through the R&RA account; b) initial support for operations and maintenance during construction provided through the R&RA account; and c) implementation support provided through the MREFC account. In addition, $2.0 million per year of R&RA funds are included here for cultural mitigation activities agreed to during the compliance process for the Daniel K. Inouye Solar Telescope.

[6] Pre-construction planning includes funding for potential next generation multi-user facilities. Not included in this line are Regional Class Research Vessels, shown here under the Academic Research Fleet.

[7] Funding for the National Radio Astronomy Observatory (NRAO) includes operation and maintenance support for the Atacama Large Millimeter Array (ALMA).

[8] Funding for Research Resources includes support for the operation and maintenance of minor facilities, infrastructure and instrumentation, field stations, museum collections, etc.

National Science Foundation Current Authorizations

(Dollars in Millions)

LEGISLATION	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Authorization Levels FY 2014	FY 2015	FY 2016
National Science Foundation Act of 1950 (P.L.81-507)[1]						
Scholarships and Graduate Fellowships				*within limits of funds made available for this purpose*		
General Authority				*within the limits of available appropriations*		
Administering Provisions				*to make such expenditures as may be necessary within the limit of appropriated funds*		
International Cooperation and Coordination with Foreign Policy						
Contract Arrangements				*utilize appropriations available*		
SBIR and STTR reauthorized under the National Defense Authorization Act for Fiscal Year 2012, (P.L. 112-81)						
Small Business Innovation Research (SBIR) Program[2]	**$139.76**	**$155.64**	**$169.01**	*2.8% of research funds in 2014, 2.9% in 2015, 3.0% in 2016*		
Small Business Technology Transfer (STTR) Program[2]	**$20.24**	**$21.47**	**$25.35**	*0.40% of research funds in 2014 and 2015, 0.45% in 2016*		

[1] Organic language establishing NSF.

[2] SBIR and STTR are authorized through September 30, 2017.

RESEARCH AND RELATED ACTIVITIES (R&RA) $6,186,300,000
+$252,660,000 / 4.3%

The FY 2016 Budget Request for the Research and Related Activities (R&RA) Appropriation is $6,186.30 million, an increase of $252.66 million above the FY 2015 Estimate level of $5,933.65 million. Funding within the R&RA Appropriation enables U.S. leadership and progress across the frontiers of scientific and engineering research and education.

In FY 2016, NSF's longstanding commitment to making investments in learning and discovery that will grow our economy, sustain our competitive advantage, and enable America to remain the world leader in innovation. It embraces the challenge of ensuring that scientific discovery and technological breakthroughs remain the primary engines for expanding the frontiers of human knowledge and responding to the challenges of the 21st century.

In FY 2016, funding within the broad and flexible R&RA account includes agency-wide support for research priorities such as advanced manufacturing, clean energy technology, cyberinfrastructure, cybersecurity, resilience to extreme natural and man-made events, and cognitive science and neuroscience. Also included is ongoing support for young scientists and engineers engaged in research and teaching at the forefront of science, technology, engineering, and mathematics.

R&RA Funding

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Change over FY 2015 Estimate Percent
Biological Sciences	$720.84	$731.03	$747.92	$16.89	2.3%
Computer & Information Science & Engineering	892.60	921.73	954.41	32.68	3.5%
Engineering	833.12	892.31	949.22	56.91	6.4%
Geosciences	1,321.32	1,304.39	1,365.41	61.02	4.7%
Mathematical & Physical Sciences	1,267.86	1,336.72	1,366.23	29.51	2.2%
Social, Behavioral & Economic Sciences	256.84	272.20	291.46	19.26	7.1%
Office of International Science and Engineering	48.31	48.52	51.02	2.50	5.2%
Integrative Activities	433.12	425.34	459.15	33.81	7.9%
U.S. Arctic Research Commission	1.30	1.41	1.48	0.07	5.0%
Total, R&RA	**$5,775.32**	**$5,933.65**	**$6,186.30**	**$252.66**	**4.3%**

Totals may not add due to rounding.

RESEARCH AND RELATED ACTIVITIES

Appropriations Language

For necessary expenses in carrying out the National Science Foundation Act of 1950 (42 U.S.C. 1861 et seq.), and Public Law 86-209 (42 U.S.C. 1880 et seq.); services as authorized by section 3109 of title 5, United States Code; maintenance and operation of aircraft and purchase of flight services for research support; acquisition of aircraft; and authorized travel; ~~$5,933,645,000,~~*$6,186,300,000*, to remain available until September 30, ~~2016,~~*2017*, of which not to exceed ~~$520,000,000~~*$540,000,000* shall remain available until expended for polar research and operations support, and for reimbursement to other Federal agencies

for operational and science support and logistical and other related activities for the United States Antarctic program: *Provided,* That receipts for scientific support services and materials furnished by the National Research Centers and other National Science Foundation supported research facilities may be credited to this appropriation.: ~~*Provided further*, That not less than $159,690,000 shall be available for activities authorized by section 7002(c)(2)(A)(iv) of Public Law 110-69.~~

Research and Related Activities
FY 2016 Summary Statement
(Dollars in Millions)

	Enacted/ Request	Unobligated Balance Available Start of Year	Unobligated Balance Available End of Year	Adjustments to Prior Year Accounts	Transfers	Obligations Actual/ Estimates
FY 2014 Appropriation	$5,808.92	$10.16	-$57.66	$21.18	-$7.28	$5,775.32
FY 2015 Estimate	5,933.65	57.66				5,991.31
FY 2016 Request	6,186.30					6,186.30
$ Change from FY 2015 Estimate						194.99
% Change from FY 2015 Estimate						3.3%

Totals may not add due to rounding.

Explanation of Carryover

Within the **Research and Related Activities (R&RA)** account, $57.66 million (including $5.60 million in reimbursable funds) was carried over into FY 2015. Obligation of all of these funds is expected by the end of the second quarter of FY 2015, unless noted otherwise.

- Directorate for Engineering (ENG) carried over $18.07 million.
  - $8.47 million is for the solicitation NSF14-557, Decision Frameworks for Multi-Hazard Resilient and Sustainable Buildings (RSB), which had a proposal deadline date of July 24, 2014. Programs involved include Network for Earthquake Engineering Simulation (NEES) Operations and Research, Hazard Mitigation and Structural Engineering, Geotechnical Engineering, Engineering and Systems Design, and Systems Science. This solicitation replaces the annual NEES Research solicitation as the program undergoes the transition from NEES to the follow-on facility.
  - $3.09 million is for Sustainability Research Networks (SRN) connected to the SRN solicitation (14-534), which was released later than anticipated. This competition covers both FY 2014 and FY 2015.
  - $6.51 million is for awards related to the Brain Research through Advancing Innovative Neurotechnologies (BRAIN) Initiative, Early Concept Grant for Exploratory Research (EAGER), joint partnership with the Air Force Office of Scientific Research (AFOSR), and Dear Colleague Letters (DCLs) for other items that were unable to be processed before the end of the fiscal year.

- Directorate for Mathematical and Physical Sciences (MPS) carried over $29.81 million.
  - MPS carried over $29.81 million for the Materials Research Science and Engineering Centers (MRSEC) awards in the Division of Materials Research. Awards were not ready for obligation before the close of FY 2014.

- Integrative Activities (IA) carried over $1.67 million.
  - $1.67 million is for Evaluation and Assessment Capability (EAC). This amount includes funding for the Graduate Research Postdoctoral Fellowship program pilot longitudinal monitoring/data

collection, information system to store evaluation reports and statements of work, development of internal EAC website, NSF Innovation Corps (I-Corps™) longitudinal data collection for I-Corps™ Teams (evaluation and initial data collection system), portfolio analysis pilots, and the G8 meeting.

- The carryover associated with R&RA includes $100,018 for the operations of the National Coordination Office/Networking and Information Technology Research and Development, and $20,354 for the operations of the National Nanotechnology Coordination Office.

- Within R&RA, $5.60 million of incoming two-year interagency funds were carried over.

- The remaining R&RA carryover of $2.39 million consists of funds from throughout the Foundation for projects that were not ready for obligation in FY 2014.

DIRECTORATE FOR BIOLOGICAL SCIENCES (BIO) $747,920,000
+$16,890,000 / 2.3%

BIO Funding
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Molecular & Cellular Biosciences (MCB)	$129.32	$134.16	$136.21	$2.05	1.5%
Integrative Organismal Systems (IOS)	215.21	213.71	215.40	1.69	0.8%
Environmental Biology (DEB)	138.70	143.49	144.76	1.27	0.9%
Biological Infrastructure (DBI)	131.81	142.60	145.41	2.81	2.0%
Emerging Frontiers (EF)	105.79	97.06	106.14	9.08	9.4%
Total, BIO	**$720.84**	**$731.03**	**$747.92**	**$16.89**	**2.3%**

Totals may not add due to rounding.

About BIO

The Directorate for Biological Sciences (BIO) increasingly supports more projects that address comprehensive questions involving multiple types of data acquisition and levels of analysis and many of these projects are becoming larger and more collaborative both within the biological sciences and with other fundamental disciplines. NSF is one of the few agencies where support for such integration across disciplines is possible, but achieving this requires new funding strategies and portfolio realignment within BIO. These new strategies are reflected in the FY 2016 budget.

Opportunities and Directions:

1. Systems approaches and synthetic biology (including its ecological applications and implications) are producing and employing new, widely applicable techniques and tools (e.g., Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR), a DNA editing technology) to advance the fundamental understanding of living systems, the interrelationship of genotype and phenotype, and the simultaneous drivers of ecology and evolution. This emerging area has broad scientific, economic, and societal implications and is reflected in the Research at the Interface of Biological Sciences, Mathematical and Physical Sciences (BioMaPS) investment strategy, in enhanced support for synthetic biology, and also includes opportunities in science, technology, education, and mathematics (STEM) education and broadening participation.

2. BIO participates in the Brain Research through Advancing Innovative Neurotechnologies (BRAIN) Initiative, an Administration priority, which aims to expand fundamental cognitive science and neuroscience research. With other NSF directorates (Social, Behavioral, and Economic Sciences (SBE), Mathematical and Physical Sciences (MPS), Computer & Information Science & Engineering (CISE), and Engineering (ENG)), BIO has initiated a unique program for fundamental research in neural circuits and neurotechnology development that complements BRAIN Initiative research supported by other participating agencies (National Institutes of Health (NIH) and the Defense Advanced Research Projects Agency (DARPA)). BIO's support for the BRAIN Initiative is reflected in the NSF-wide priority investment, Understanding the Brain (UtB).

3. The National Ecological Observatory Network (NEON) is a major BIO facility that will continuously stream terabytes of environmental data of regional and national significance on all scales, from organismal to continental. The MacroSystems Biology program will fund research that uses NEON

data to address macroscale research questions by supporting collaborative teams with larger awards than are possible in other core programs. As NEON construction completes and full operations begin, collaborations with other environmental facilities such as the Long Term Ecological Research (LTER) Network, Critical Zone Observatories (CZO), and the Ocean Observatories Initiative (OOI) will be actively explored. NEON will be an essential observatory for anticipating and adapting to large-scale planetary change. In FY 2016, NEON is projected to complete construction and significant components of operations will be commissioned, including STREON – the stream ecology experiment – and aquatics sites across the country. NEON operations will represent a major change to the BIO portfolio, with up to 5.9 percent of BIO's total funding dedicated to operations and maintenance of the facility. It is expected that NEON science – through macrosystems and other core programs – will be an important investment strategy for the NSF-wide priority Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS).

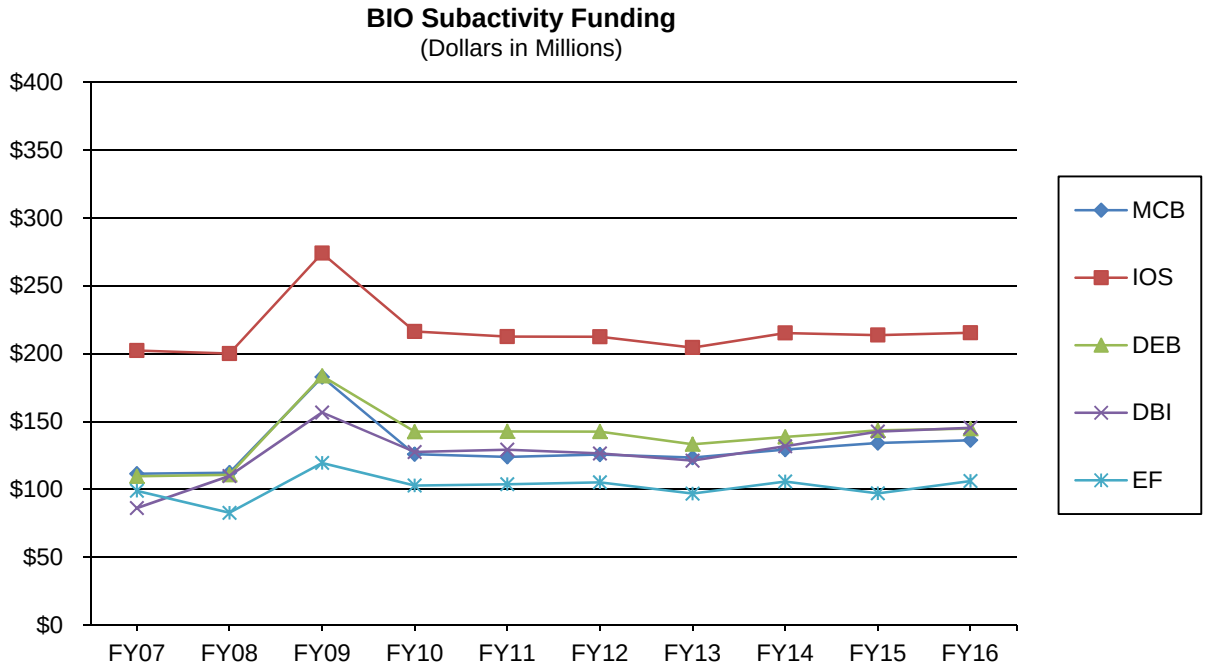
4. BIO invests in diverse cyberinfrastructure activities for the biological sciences, including: Synthesis Centers, iPlant, iDigBio, NEON, GoLife, and the BRAIN Initiative. In addition, the Division of Biological Infrastructure (DBI) focuses specifically on software, databases, and the creation of virtual communities to enable diverse types of biological research. DBI awards emphasize research areas that complement ongoing activities and infrastructure supported in other BIO divisions and other NSF directorates, such as the investment in BioData (BIO's contribution to the Cyberinfrastructure Framework for 21st Century Science, Engineering, and Education (CIF21)), which will network biological research facilities and related collaborative activities with other relevant legacy and new extant data sources and biological resources. This will enable the synthesis of fundamental research data and new knowledge from a wide spectrum of activities including large-scale molecular, phylogenetic, environmental, and behavioral databases, as well as digitized collections of biological specimens.

5. BIO has been a consistent innovator within NSF in the approach to merit review and in new ways to advance science. BIO has developed such signature programs as Research Collaboration Networks (RCN) – virtual communities of investigators who share ideas, results, and best practices; Synthesis Centers; Ideas Labs for high risk multidisciplinary research projects; and the creative application of Early-concept Grants for Exploratory Research (EAGER) awards to emerging research areas (e.g., neurotechnology and neural circuits and the Basic Research to Enable Agricultural Development (BREAD) program). These strategies will be important components of BIO's investments to broaden participation through the RCN-Undergraduate Biology Education (UBE) program and to support the BRAIN Initiative.

6. BIO continues to emphasize investments in the Five Grand Challenges in Biology: 1) synthesizing life-like systems; 2) understanding the brain; 3) predicting organisms' characteristics from their DNA sequences; 4) elucidating interactions between the earth, its climate, and its biosphere; and 5) understanding biological diversity. These challenges are supported by the divisions for Molecular and Cellular Biosciences (through the Molecular Biophysics, Cellular Dynamics and Function, Genetic Mechanisms, and Systems and Synthetic Biology clusters), Environmental Biology (through the Ecosystem Science, Evolutionary Processes, Population and Community Ecology, and Systematics and Biodiversity Science clusters), and Integrative Organismal Systems (through the Behavioral Systems, Developmental Systems, Neural Systems, and Physiological and Structural Systems clusters), as well as through NEON and cross-NSF activities such as BioMaPS, the BRAIN Initiative, and UtB.

BIO provides about 66 percent of the federal funding for non-medical, basic research at academic institutions in the life sciences, including environmental biology, a research area critical for addressing

questions related to climate science.



FY 2009 funding reflects both the FY 2009 omnibus appropriation and funding provided through the American Recovery and Reinvestment Act of 2009 (P.L. 111-5).

FY 2016 Summary by Division

- MCB's FY 2016 Request ($136.21 million) will focus support for research at the interface of biology with the quantitative and predictive sciences to enhance understanding into the fundamental molecular and cellular principles of life representing the heart of all grand challenges and bioeconomy. MCB will also fund advanced manufacturing through the NSF-wide investment priorities BioMaPS and Cyber-enabled Materials, Manufacturing, and Smart Systems (CEMMSS). MCB will support research on computational design of biomaterials, and the development of tools and standards in synthetic biology as an approach to the rapid development of biomanufacturing platforms. MCB's contributions include research such as computational mining of the biological data from diverse biological systems to identify inspirations for the design and synthesis of new materials with defined properties and capabilities, and predictive synthetic biology to design new nanomaterials, particularly based on photosynthesis and other biological processes.

- IOS's FY 2016 Request ($215.40 million) will focus on basic neuroscience research directed towards understanding the development, modification, and activity of the healthy brain during complex natural behaviors. A significant proportion ($13.50 million) of BIO's BRAIN Initiative activities are funded through the Emerging Frontiers division, but support and complement IOS' investment in neuroscience in collaboration with other partners across NSF. In FY 2016, the enhanced BRAIN activities will focus on opportunities for large-scale data integration, data re-use and synthesis, extending theory, and leveraging the investments in BRAIN EAGERs made in FY 2014 and FY 2015. IOS core programs will continue to support research related to the Five Grand Challenges. All IOS programs, but especially the Plant Genome Research Program (PGRP), will encourage use of synthetic biology approaches to alter and manipulate the complex interactions of components of cells and organisms to reveal systems dynamics and emergent properties. IOS programs will emphasize

multi-scale integration through mathematical, computational, experimental, and theoretical approaches to understand how characteristics of individual organisms and their emergent properties arise from their DNA sequences.

- DEB's FY 2016 request ($144.76 million) will emphasize fundamental research on complex ecological and evolutionary processes and on how their relationships and feedbacks shape biodiversity and explain the dynamics of populations, species, communities, and ecosystems across broad spatial, temporal, and phylogenetic scales. This research will improve our ability to understand the reciprocal interactions between living systems and a changing environment, and inform essential considerations of environmental sustainability. A proportion ($15.0 million) of NEON research activities are funded through the Emerging Frontiers division, but will support and complement research through DEB core programs with an emphasis on expanding the community of researchers addressing macro-scale environmental questions. DEB will expand research in synthetic biology to support new capabilities that provide an unprecedented opportunity to advance understanding in evolutionary ecology and the processes linking genome with phenome, and to enable the responsible development of this biotechnology. DEB will sustain support for the Dimensions of Biodiversity and the Dynamics of Coupled Natural and Human Systems (CNH) programs, and will continue to invest in coordinated efforts to link legacy and current data streams to enable integrative synthesis.

- DBI's FY 2016 Request ($145.41 million) empowers biological discovery by supporting the development and enhancement of biological research resources, human capital, and centers. It includes sustaining support for the Advanced Digitization of Biodiversity Collections (ADBC) program and continued support for centers including the most recently BIO-funded Science and Technology Center (STC), Center for Biology with X-Ray Lasers (XFEL). In addition, support will be enhanced for biological research resources in CIF21 through increased funding for the BioData activity. Support also will be enhanced for human capital focused activities through active research participation by undergraduate students through the Research Experiences for Undergraduates (REU) Sites program.

- EF's FY 2016 Request ($106.14 million) supports a number of limited-term activities, thus allowing for repurposing of funds towards new emphases including support for facilities. NSF-wide activities supported within EF include: UtB, BioMaPS, and the new INFEWS activity. EF also will maintain investment in Dimensions of Biodiversity, as the last BIO program within SEES as this activity continues to phase-down. In addition, enhanced support for research related to synthetic biology (within MCB, IOS, and DEB) will be leveraged via additional funds for this activity centered in EF. In FY 2016, NEON Operations and Maintenance (O&M) increases to a total of $44.04 million, as construction is completed and NEON ramps up operations. Support for the MSB program and first NEON science ($15.0 million) will be enhanced as NEON continues to phase into operations and standardized cross-continental data is available for research.

Major Investments

BIO Major Investments
(Dollars in Millions)

Area of Investment	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
BioMaPS	$14.31	$14.31	$16.81	$2.50	17.5%
CAREER	38.56	36.43	38.25	1.82	5.0%
CEMMSS	4.75	4.99	5.48	0.49	9.8%
Advanced Manufacturing	*2.60*	*2.84*	*3.33*	*0.49*	*17.3%*
Clean Energy Technology	46.00	47.20	48.39	1.19	2.5%
CIF21	6.16	3.75	8.39	4.64	123.7%
I-Corps™	0.95	1.00	1.00	-	-
NSF INCLUDES	-	-	1.40	1.40	N/A
INFEWS	-	-	7.50	7.50	N/A
INSPIRE	0.32	1.00	1.00	-	-
IUSE	1.82	2.50	2.50	-	-
NRT[1]	3.12	3.39	2.33	-1.06	-31.3%
SEES	31.00	21.00	17.50	-3.50	-16.7%
Understanding the Brain	33.60	37.77	43.40	5.63	14.9%

Major investments may have funding overlap and thus should not be summed.

[1] Outyear commitments for Integrative Graduate Education and Research Traineeship (IGERT) are included in the NRT line and are $3.12 million in FY 2014, $2.0 million in FY 2015, and $1.62 million in FY 2016.

- BioMaPS ($16.81 million): This NSF-wide investment seeks to discover fundamental new knowledge to enable innovation in national priorities such as clean energy, climate science, and advanced manufacturing. In FY 2016, BIO will increase support for this activity (+$2.50 million over the FY 2015 Estimate) by enhancing and broadening its research investment. One area of emphasis will be synthetic biology, which is a convergent area at the intersection of biology, engineering, and physical sciences that informs our ability to design and build novel biological functions and systems using engineering principles. Synthetic biology promises to develop a wide range of economically viable agricultural, industrial, environmental, energy, and health applications. Because many synthetic biology products, such as food additives, biofuels, drugs, and applications to prevent insect borne diseases are now close to commercialization, it is becoming increasingly essential and urgent that we understand environmental, evolutionary, and societal contexts of synthetic biology products and organisms. In addition, synthetic biology is also opening up new avenues of enquiry and experimental approach that promise to advance fundamental knowledge about biological processes linking genome to phenome.

- CAREER ($38.25 million): BIO's CAREER awards support young investigators who exemplify the role of teacher-scholars through outstanding research, excellent education, and the integration of education and research within the context of the mission of their organizations. In FY 2016, BIO will increase support for CAREER by $1.82 million over the FY 2015 Estimate.

- CEMMSS ($5.48 million): BIO's support (+$490,000 over the FY 2015 Estimate) will enable breakthrough materials through research on topics such as computational mining of genomic data from diverse biological systems to identify inspirations for design of new materials, or predictive synthetic biology to design new nanomaterials, particularly based on photosynthesis and other biological processes. In FY 2016, BIO will continue its interagency collaborations in the area of engineering biology related to advanced biomanufacturing. ENG and BIO will continue to collaborate in funding a new Industry/University Cooperative Research Center (I/UCRC) in the area. A National Academies study on the Industrialization of Biology, co-funded by ENG and BIO, will be completed in FY 2015.

- Advanced Manufacturing ($3.33 million): BIO will support advanced manufacturing research through BioMaPS and CEMMSS. In collaboration with ENG, BIO supports advances in standards in synthetic biology and the development of tools that will advance biomanufacturing and the development of novel biomaterials that will support the development of a thriving bioeconomy.

- Clean Energy Technology ($48.39 million): BIO support for clean energy technology increases by $1.19 million over the FY 2015 Estimate for fundamental research in areas such as systems and synthetic biology to streamline and scale the metabolic and energetic potential of living organisms (e.g., microbes, fungi, algae, and plants) to produce non-petroleum based sources of important chemicals/materials, feed stocks, and fuels. Investigations to assess the impact of fuel and/or bio-renewable chemical production on genome stability, fitness, and phenotype of the production organisms are of interest, as are studies to assess the potential environmental impacts of these technologies. A Dear Colleague Letter was released in FY 2015 to encourage the submission of proposals in the area of clean energy research.

- CIF21 ($8.39 million): BIO support, an increase of $4.64 million over the FY 2015 Estimate, will be partnered with the CISE programs Software Infrastructure for Sustained Innovation (SI^2) and Data Infrastructure Building Blocks (DIBBS). In FY 2016, SI^2 will begin to focus on software infrastructure for major projects and awards including STCs, iPlant, and Major Research Facilities and Construction (MREFC) projects such as NEON. The DIBBS program's expanded scope includes: data reproducibility; interoperability of specific research data; sustainability plans; and exploration of innovative economic/operating models for archiving and curation.

- I-Corps ($1.0 million): BIO will sustain support for I-Corps nodes and grants that test the feasibility of commercial prototypes developed from NSF/BIO-supported research.

- NSF INCLUDES ($1.40 million): In FY 2016, BIO will participate in this NSF-wide effort to increase the preparation, participation, advancement, and potential contributions of those who have been traditionally underserved and/or underrepresented in STEM fields.

- Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS) ($7.50 million): The food-energy-water emphasis will be stressed in NSF-wide and BIO specific programs, such as CNH, and MSB. NEON includes both a stream ecology experiment (STREON) and aquatics sites as part of the observatory design. As NEON continues to phase into operations as construction funding is completed in FY 2016, research findings as part of the embedded NEON STREON experiment and support for research proposals utilizing data streaming from the observatory related to aquatics will inform this NSF-wide activity.

- INSPIRE ($1.0 million): In FY 2016, BIO will continue to invest in INSPIRE awards that address complicated scientific problems at the interface between disciplines.

- IUSE ($2.50 million): In FY 2016, support will transfer from EF to DBI to continue to support activities related to undergraduate biology education including continuation of The Partnership for Undergraduate Life Sciences Education (PULSE), RCN-UBE.

- NRT ($2.33 million): BIO will participate in the NSF-wide program, NSF Research Traineeship (NRT), which is a modernization of the Integrative Education and Research Traineeship (IGERT) program. For more information regarding NRT, see the Major Investments in Science, Technology, Engineering, and Mathematics (STEM) Graduate Education narrative in the NSF-Wide Investments chapter.

- Science, Engineering, and Education for Sustainability (SEES) ($17.50 million): BIO will sustain support for the Dimensions of Biodiversity while phasing down support (-$3.50 million below the FY 2015 Estimate) for other SEES programs.

- Understanding the Brain (UtB) ($43.40 million): BIO increases support, +$5.63 million above the FY 2015 Estimate, for this cross-foundation activity that draws together under one management framework ongoing activities and NSF's contributions to the Administration's BRAIN Initiative. The increase, focused in Emerging Frontiers (EF), supports research on mapping circuits that drive behavior in a variety of organisms. Support will be included for activities related to integrative and transdisciplinary team-based brain research; data science, infrastructure, tool development for understanding the brain, and specialized training and professional development in multi-disciplinary and international research and large-scale data management and analysis.

BIO Funding for Centers Programs and Facilities

BIO Funding for Centers Programs

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, Centers Programs	**$42.75**	**$38.92**	**$34.73**	**-$4.19**	**-10.8%**
Centers for Analysis & Synthesis (DBI)	21.35	20.80	18.40	-2.40	-11.5%
Nanoscale Science & Engineering Centers (DBI)	6.33	6.33	6.33	-	-
Science & Techology Centers (DBI)	13.32	10.16	10.00	-0.16	-1.5%
Science of Learning Centers (DBI)	1.75	1.63	-	-1.63	-100.0%

Totals may not add due to rounding.

For detailed information on individual centers, please see the NSF-Wide Investments chapter.

- Centers for Analysis and Synthesis: Funding decreases by $2.40 million below the FY 2015 Estimate, to a total of $18.40 million. The program will support three centers in FY 2016. The decreased support represents the planned phase-down for two centers: the Plant Science Cyberinfrastructure Collaborative (iPlant) and the National Institute for Mathematical and Biological Synthesis (NIMBioS).
- Nanoscale Science and Engineering Centers (NSEC): Support will be continued for the Centers for Environmental Implications of Nanotechnology (CEIN).

- Science and Technology Centers (STCs): BIO will maintain support for two STCs in FY 2016 for a total of $10.0 million. The Bio/computational Evolution in Action CONsortium (BEACON) increases to a total of $5.0 million. Support is sustained for the Center for Biology with X-Ray Lasers (X-Fel) at $5.0 million.

BIO Funding for Facilities

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, Facilities	**$27.24**	**$43.35**	**$49.39**	**$6.04**	**13.9%**
National Nanotechnology Coordinated Infrastructure (NNCI)	-	0.35	0.35	-	-
National Nanotechnology Infrastructure Network (NNIN)	0.35	-	-	-	N/A
Cornell High Energy Synchrotron Source (CHESS)	5.00	5.00	5.00	-	-
National Ecological Observatory Network (NEON)	21.89	38.00	44.04	6.04	15.9%

Totals may not add due to rounding.

For detailed information on individual facilities, please see the Facilities chapter.

- Funding for NEON O&M ramps up in FY 2016 (+$6.04 million over the FY 2015 Estimate, to a total of $44.04 million) as sites are commissioned and validated for delivery of science data through a central cyberinfrastructure portal. NEON is in its sixth and final year of construction and is building a series of 106 sites over twenty domains across the U.S. The research community began early science using NEON with the initiation of operations in FY 2015 and the availability of NEON soils and remote sensing data. The NEON web portal (active since FY 2015) is providing data to researchers from NEON sensors and citizen scientists. Release of a NEON data products catalog, NEON protocols, and publications is ushering in a new paradigm for ecological research. The NEON Citizen Science Academy is providing accredited training for educators and professional development for federal agency staff.
- NNIN/NNCI: BIO investment for the National Nanotechnology Infrastructure Network (NNIN) transitions in FY 2015 to the National Nanotechnology Coordinated Infrastructure (NNCI), the successor to NNIN.
- Cornell High Energy Synchrotron Source (CHESS): BIO support for CHESS will be sustained since it is an important synchrotron facility for studying biological molecules, training beam-line scientists, and providing outreach activities, including a program targeting Native American students.

BIO Funding Profile

	FY 2014 Actual Estimate	FY 2015 Estimate	FY 2016 Estimate
Statistics for Competitive Awards:			
Number of Proposals	4,788	5,000	5,300
Number of New Awards	1,276	1,250	1,300
Funding Rate	27%	25%	25%
Statistics for Research Grants:			
Number of Research Grant Proposal	3,829	4,000	4,200
Number of Research Grants	945	920	970
Funding Rate	25%	23%	23%
Median Annualized Award Size	$177,930	$182,300	$186,900
Average Annualized Award Size	$216,855	$222,300	$227,900
Average Award Duration, in years	3.2	3.2	3.2

Summary and Funding Profile

In FY 2016, the number of full research grant proposals is projected to increase slightly compared to FY 2015 estimated submissions. BIO will continue with the current proposal submission process: a preliminary proposal step was implemented in two of four divisions in BIO in FY 2012, and three divisions moved to annual full proposal cycles in FY 2013. Pre-proposals are not counted in the numbers cited in the funding profile above. In FY 2014, BIO received approximately 4,000 pre-proposals. When pre-proposals are included in the funding profile, funding rates are significantly lower, with some program areas below 10 percent. BIO expects to award about 970 research grants. Average annual award size will slightly increase to reflect increasing costs of research; duration will remain constant.

In FY 2016, BIO will invest $34.73 million in centers, accounting for 4.6 percent of the BIO budget. In FY 2016, total centers funding will decrease $4.19 million from the FY 2015 Estimate. The phase-down for two centers, iPlant and NIMBioS, continues along with the sunsetting of C-MORE and the BIO-supported Science of Learning Center.

Operations and maintenance funding for NEON, the only BIO-managed facility, comprises 5.9 percent of BIO's FY 2016 Request.

Program Monitoring and Evaluation

- BIO developed a Transparency and Accountability Plan in May 2014. This plan includes several steps that build on prior best practices that have been implemented across the directorate. First, every program holds a post-panel briefing that includes the program directors, the division director, and the science advisor (if the division has one) to discuss proposed awards and declinations. The briefing includes an analysis of the current portfolio and proposed awards for scientific and demographic information.
- Since FY 2014, the divisions submit narrative annual reports to BIO's Office of the Assistant Director (OAD) that provide information on the whole division's activities. These are then summarized in the form of a directorate-wide report.

- BIO has established a standing BIO Portfolio Analysis Working Group (BPAWG), which is charged with carrying out an annual portfolio analysis at the directorate level as well as retrospective analyses as needed.
- BIO held two directorate-wide portfolio discussions in FY 2014. The first focused on the emerging scientific gaps, opportunities, and synergies across the directorate. The second discussion focused on the types of tools available and the kind of queries that are possible. The result was a summary of scientific opportunities across divisions and the decision to obtain an enhanced IT tool for better portfolio analysis through text mining. The outputs to be analyzed across FY 2015 – FY 2016 will inform the FY 2017 budget request.

Committee of Visitors (COV):

- In FY 2014, BIO held three COVs: MCB, IOS, and a third reviewed two programs in Emerging Frontiers (EF):
  - The MCB COV recommended that BIO increase oversight on the use of the EAGER mechanism, including requiring recommendations from two or more program directors to ensure that funding is used for early stage, exploratory, potentially transformative projects.
  - In June 2014, IOS convened a COV to evaluate IOS core programs and processes over the period of FY 2011-2013. The COV commended the division on the implementation of the preliminary proposal process and new data analytic tools that are in part aimed at portfolio analysis. Among other recommendations, the COV recommended increased staffing to mitigate rising workloads; increased documentation of processes; increasing participation of smaller, primarily undergraduate institutions and of members of underrepresented groups; continued funding to support mid-career awards; and an evaluation of the impacts of IOS awards over time.
  - The EF COV presented a favorable evaluation of the operations and management of the MSB and the ADBC programs. The COV recommendations included: establishing a long-term home for integrative, highly collaborative science, e.g. MSB; encouraging interagency collaboration relating to collections; and developing a long-term strategic look at data infrastructure needs and plans.
- In FY 2015, a COV will review DEB.
- In FY 2016, a COV will review DBI.

Workshops and Reports:

- Division of Molecular and Cellular Biosciences:
  - In collaboration with the Division of Chemical, Bioengineering, Environmental, and Transport Systems (CBET) within the Directorate for Engineering (ENG), jointly supported an award in FY 2013 for a preliminary study on **"**Industrialization of Biology: A Roadmap to Accelerate Advanced Manufacturing of Chemicals." The National Research Council of the National Academy of Sciences, through its Board on Chemical Sciences and Technology and its Board on Life Sciences, will identify key gaps in knowledge, tools, techniques and systems needed to realize the potential for advanced manufacturing via biological systems, using manufacturing of chemicals as the case study. A report will be available in the fourth quarter of FY 2015.
  - MCB, CBET, and the Division of Chemistry (CHE) within the Directorate for Mathematical and Physical Sciences (MPS) jointly funded a workshop entitled "Design, engineering and selection of novel proteins," held in May 2014, that supports CEMMSS. The workshop brought together scientists and engineers from diverse fields to address advances in protein (material) design. The report is expected in the fourth quarter of FY 2015.
  - Partnered with the Industrial Innovation and Partnerships Division (IIP) within ENG to work with other funding and regulatory agencies and representatives from Office of Science and Technology Policy (OSTP) to convene a workshop in July 2014 addressing case studies in synthetic biology

to enable horizon scanning and proactive conversations about the coordinated regulatory framework that governs products of synthetic biology.

- MCB, CBET, and the Division of Social and Economic Sciences (SES) within SBE jointly supported an award titled "Workshop on Research Agendas in the Societal Aspects of Synthetic Biology". The workshop was conducted in November 2014 and a final report will be delivered in the second quarter of FY 2015. The workshop and report formulated recommendations for the conduct of social science, risk assessment, and economic research that will facilitate the responsible practice of the science and technology associated with synthetic biology.
- MCB and the Division of Mathematical Sciences (DMS) in MPS jointly funded an award late in FY 2014 for 5 years entitled "Building a Community to Pursue Quantitative Cell Biology". The goal of the project is to bring together researchers in a series of workshops and focused meetings to advance the use of quantitative and theory driven, predictive approaches to the study of cell biology. Graduate and undergraduate students will be included in workshops as well as laboratory exchanges to ensure education and training of the next generation of scientists at the interface of mathematical and biological sciences. A first report is due in May 2015.

- Division of Integrative Organismal Systems:
  - Held a workshop during the summer of 2014 on the future of Animal Behavior programmatic areas focused on multiscale integration. A final report was received in early FY 2015. The report recognized the need for integration of neural, genetic, physiological, ecological, and evolutionary studies in integrative animal behavior research. Among other recommendations, the report recommended development of field-compatible technological advances that allow the measurement of physiological (e.g. hormones, heart rates) or neural changes (e.g. neurotransmitter release) in real time in non-tethered animals.
  - Organized and supported a BRAIN EAGER awardees meeting in early FY 2015. The meeting was a venue for these principal investigators (PIs) to discuss recent outcomes from their high risk/high reward research on emergent properties of neural circuit activity, to network with other investigators, and to potentially establish new collaborations.
  - A workshop is planned for the summer of FY 2015 to facilitate discussions among faculty from Primarily Undergraduate Institutions (PUI) on identifying aspects of the BRAIN Initiative that may be particularly relevant to conducting research and engaging undergraduate researchers at PUIs, to identify barriers that could prevent PUI faculty and students from contributing to this effort, and to propose solutions to such impediments.
  - In collaboration with MCB and DMS, IOS is planning one or two workshops later in FY 2015 on multi-scale integration in organisms. The workshops will be aimed at identifying opportunities where mathematical modeling approaches would enhance our understanding of multi-scale integration and emergent properties of organisms.
- Division of Environmental Biology:
  - Funded a series of workshops in 2012 and 2013 through an award titled "Frontiers in Ecosystem Science: Energizing the Research Agenda," to catalyze the Ecosystem Science community to develop an agenda of major directions for future research with a focus on interdisciplinary topics. A final report is expected in the fourth quarter of FY 2015.
  - The Long Term Ecological Research (LTER) program in DEB funded a "Task Force to re-envision the network office of the Long Term Ecological Research Program." In FY 2013, this award supported a team of researchers to engage diverse environmental science communities in discussions about, and to gather input on, the future structure and function of the LTER Network Office. A preliminary report was submitted in 2014, and the group's final report was accepted by NSF early in calendar year 2015. The report will help to inform future directions of the network office and the LTER network.
  - DEB, MCB, and CBET jointly supported an award in FY 2013 titled "Creating a Research Agenda for the Ecological Implications of Synthetic Biology," which supports workshops to set a

national research agenda for environmental implications of synthetic biology. The workshops were conducted in January-February 2014 and a final report was published in 2014.[1]

- Funded a workshop in June 2014 to advance the use of genetic information in classifying fungi. This workshop will consider the technical, analytical, and taxonomic/nomenclatural challenges and opportunities presented by methods that use sequence data to recognize and identify fungi, either from fungal cultures, fruiting bodies, or directly the environment. A report is expected in early calendar year 2015.
- Funded an international workshop in FY 2014 to take place in the first half of calendar year 2015 to advance the theory and practice of meta-analysis of ecological data from the international literature for understanding sustainable development, biodiversity, and ecosystem function. A review paper examining best practices is expected to be produced.
- DEB is funding a workshop to be held in the fall of 2015 on "what works" in broadening participation. It will occur in the Washington, DC area, involve diverse stakeholders, establish an online community, and help focus priorities within DEB for a potential new solicitation on broadening participation.
- DEB funded a three-year series of workshops in FY 2014 titled “The future of comparative biology in a phylogenetic age: Enabling the power and potential of the genealogy of life” which will bring together diverse experts in phylogenetics, data visualization, and computational sciences to identify the major challenges in generating, storing, serving and visualizing the genealogy of life. Numerous products are expected over the course of the workshops being held in calendar years 2015 and 2016, and will be maintained on a central web presence to be launched in early 2015.

The Performance chapter provides details regarding the periodic reviews of programs and portfolios of programs by external Committees of Visitors and directorate Advisory Committees. Please see this chapter for additional information.

Number of People Involved in BIO Activities

	FY 2014 Actual Estimate	FY 2015 Estimate	FY 2016 Estimate
Senior Researchers	4,194	4,300	4,400
Other Professionals	1,619	1,600	1,600
Postdoctorates	1,467	1,500	1,500
Graduate Students	2,886	2,900	3,000
Undergraduate Students	4,360	4,400	4,500
Total Number of People	**14,526**	**14,700**	**15,000**

[1] www.wilsoncenter.org/article/ecological-risk-research-agenda-for-synthetic-biology

DIVISION OF MOLECULAR AND CELLULAR BIOSCIENCES (MCB)

$136,210,000
+$2,050,000 / 1.5%

MCB Funding
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, MCB	**$129.32**	**$134.16**	**$136.21**	**$2.05**	**1.5%**
Research	**127.72**	**132.55**	**134.37**	**1.82**	**1.4%**
CAREER	15.79	14.96	15.76	0.80	5.3%
Education	**1.61**	**1.61**	**1.84**	**0.23**	**14.3%**

Totals may not add due to rounding.

MCB supports fundamental research and related activities that promote quantitative, predictive, and theory-driven understanding of complex living systems at the molecular, subcellular, and cellular levels. MCB gives high priority to interdisciplinary research projects that integrate theory, methods, and technologies at the interface with physical sciences, mathematics, computational sciences, and engineering to address major biological questions. Using this approach, MCB seeks to support research that addresses important questions in fundamental cell and molecular biology, including the emerging areas of synthetic biology, multi-scale integration, molecular and cellular evolution, and quantitative prediction of phenome from genomic information.

The division also supports development of methods and resources that will be used to tackle major biological questions, such as how non-living systems converge to create emergent properties of living systems, and the molecular correlates of environmental changes. MCB funds research that employs a range of experimental approaches – including *in vivo*, *in vitro* and *in silico* strategies – and a broad spectrum of model and non-model organisms, especially microbes and plants.

MCB is one of the major supporters of synthetic biology in the Foundation, and collaborates with Divisions of Physics (PHY), Chemistry (CHE), Mathematics (DMS), and Materials Science (DMR) in the Directorate for Mathematical and Physical Sciences (MPS) and the Directorate for Computer and Information Science and Engineering (CISE) to develop and utilize tools from systems and synthetic biology to address basic questions including the origins of life, minimal life forms, molecular and cellular evolution, pattern formation, and robustness and stability in biological systems. In collaboration with the Directorate for Engineering (ENG), MCB supports advances in standards in synthetic biology and the development of tools that will advance biomanufacturing and development of novel biomaterials that will support the development of a thriving bioeconomy.

MCB continues to forge partnerships (including international partnerships) to support fundamental research in the cellular and molecular sciences and to provide unique educational and training opportunities for the next generation of researchers, science educators, and scientifically literate citizens.

In general, 42 percent of the MCB portfolio is available for new research grants and the remaining 58 percent funds continuing grants made in previous years.

FY 2016 Summary

All funding increases represent change over the FY 2015 Estimate.

Research

- Emphasis in MCB on research at the interface of biology with the quantitative and predictive sciences will yield insights into the fundamental molecular and cellular principles of life that provide the foundation for all of the biological sciences.
- MCB will maintain its strong support ($4.17 million) for BioMaPS through partnerships with MPS and ENG. This support will foster foundational research activities that employ interdisciplinary, quantitative, and theory-based approaches to understand the function and evolution of living systems.
- MCB will support CEMMSS research via BioMaPS at a total of $5.48 million, by supporting fundamental research on the components and processes that comprise and control biological systems at the nano to cellular scales. In addition, MCB will contribute to Advanced Manufacturing ($3.33 million) by supporting research on computational design of biomaterials, the development of tools and standards in synthetic biology as an approach to the rapid development of biomanufacturing platforms, and the foundational molecular scale research that will produce the next generation of nano-, bio-, and information technologies.
- MCB will increase its investment in synthetic biology by $1.0 million. Synthetic biology is an inherently interdisciplinary activity whose funding will complement BioMaPS and CEMMSS activities. Research in synthetic biology will enable greater understanding of the fundamental principles on which living systems operate and can be built, including molecular and cellular evolution, genomes to phenomes, ecological research, and the development of biologically inspired materials. Synthetic biology is also an important tool in developing advanced biomanufacturing capabilities. MCB will invest in partnerships with the United Kingdom Biotechnology and Biological Sciences Research Council and the European Research Agency in support of the U.S. components of joint research projects that engage synthetic biology as a mechanism to leverage international investments in this area.
- Support for early-career researchers is a BIO priority; MCB will increase investment (+ $800,000 to a total of $15.76 million) in CAREER grants.

Education

- Along with other BIO divisions, MCB increases support for Research Experiences for Undergraduates (REU) activities (+$230,000 to a total of $1.71 million).

DIVISION OF INTEGRATIVE ORGANISMAL SYSTEMS (IOS) **$215,400,000 +$1,690,000 / 0.8%**

IOS Funding
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, IOS	**$215.21**	**$213.71**	**$215.40**	**$1.69**	**0.8%**
Research	**183.94**	**183.54**	**184.57**	**1.03**	**0.6%**
CAREER	11.15	9.75	10.19	0.44	4.5%
Education	**4.59**	**5.97**	**6.63**	**0.66**	**11.1%**
Infrastructure	**26.67**	**24.20**	**24.20**	**-**	**-**
Research Resources	26.67	24.20	24.20	-	-

Totals may not add due to rounding.

IOS supports research and education aimed at understanding the structure and function of plants, animals, and microorganisms as complex systems. Activities supported by IOS focus on neural, developmental, physiological, biomechanical, and behavioral processes that characterize organisms, and how they are integrated to result in the dynamic stability of whole organisms. Achieving such a systems-level understanding of organisms is relevant to, and will help advance, the understanding of genomes to phenomes, one of five grand challenges in biology, and will require a new emphasis on interdisciplinary approaches and development of new tools. These approaches span computational, mathematical, molecular, cellular, and individual organism levels of inquiry and analysis. IOS-supported research yields important new knowledge about functional integration and responsiveness of biological systems, providing valuable insights about the control of stability and dynamics of complex systems. IOS-supported research affords new understanding of how a wide diversity of organisms will respond to environmental change to improve our understanding of the reciprocal interactions between the biological and physical-chemical drivers of global climate change.

Within IOS, support for neuroscience focuses on the basic functions of the nervous system in response to physical, physiological, and social environments using empirical, theoretical, and computational approaches. Supported research includes comparative and evolutionary approaches to expose common patterns of mechanisms underlying how organisms perceive their physical and social environment. Results of IOS-supported neuroscience will provide the information needed to enable multi-scale integration of these dynamic activities to reveal emergent properties of nervous systems.

The Plant Genome Research Program (PGRP) supports genome-scale research to accelerate discoveries of relevance to basic plant biology, as well as downstream applications of potential societal benefit, such as crop improvement, development of new sources of bio-based energy, development of sources of novel bio-based materials, and plant adaptation to global climate change. Genome-enabled technologies developed through PGRP investments are being coupled with synthetic biology approaches to explore engineering of plants as bio-manufacturing sites that produce useful products, such as oils. The Basic Research to Enable Agricultural Development (BREAD) program will continue support for basic research to test innovative, early-concept approaches and technologies for sustainable, science-based solutions to problems of agriculture in developing countries.

IOS will plan for one or two workshops on multi-scale integration in organisms in collaboration with the

Division of Molecular and Cellular Biosciences (MCB) and the Division of Mathematical Sciences (DMS) in the Directorate for Mathematical and Physical Sciences (MPS). In this way community input will be solicited to identify opportunities where mathematical modeling approaches would enhance our understanding of the integration of the vast number of non-linear interactions of components of organisms. This developing cross-disciplinary collaboration is relevant to the BioMaPS activity. Workshop outcomes will be used to develop future plans for support of this important aspect of research in genomes to phenomes.

In general, 53 percent of the IOS portfolio is available for new research grants and the remaining 47 percent funds continuing grants made in previous years.

FY 2016 Summary

All funding increases represent change over the FY 2015 Estimate.

Research

- IOS supports basic neuroscience research directed towards understanding the development, modification, and activity of the healthy brain during complex natural behaviors. In FY 2016, total funding for Understanding the Brain (UtB) will increase (+$5.63 million, to a total of $43.40 million). While a significant proportion of the UtB activities related to the BRAIN initiative will be funded through Emerging Frontiers ($13.5 million), IOS neuroscience will support the UtB activity in collaboration with other partners across BIO and NSF. In FY 2016 these activities will focus on opportunities for large-scale data integration, data re-use and synthesis, extending theory, and leveraging the investments in BRAIN EAGERs made in FY 2014 and FY 2015.
- IOS core programs will continue to support research related to the Five Grand Challenges.
- All IOS programs, but especially PGRP, will encourage use of synthetic biology (+$1.0 million in FY 2016) approaches to alter and manipulate the complex interactions of components of cells and organisms to reveal systems dynamics and emergent properties. IOS programs will emphasize multi-scale integration through mathematical, computational, experimental, and theoretical approaches to understand how characteristics of individual organisms and their emergent properties arise from their DNA sequences.
- Support for early-career researchers is a BIO priority; IOS will increase investment (+$440,000 to a total of $10.19 million) in CAREER grants.

Education

- Along with other BIO divisions, IOS increases support for Research Experiences for Undergraduates (REU) activities (+$660,000 to a total of $2.14 million).
- The Plant Genome Research Program (PGRP) will continue to provide support for the National Plant Genome Initiative (NPGI) Postdoctoral Research Fellowships Program, which is co-sponsored by NSF, the U.S. Department of Energy (DOE), and the U.S. Department of Agriculture (USDA) – Agricultural Research Service (ARS).

Infrastructure

- The IOS request maintains investments in research resources essential to PGRP, including tools for high-throughput analysis of agriculturally-important plant phenotypes under field conditions, as well as computational tools for assembly and annotation of complex genomes and their integration with associated genomic data that supports research in all IOS program. Priorities are consistent with the National Plant Genome Initiative (NPGI) 5-year plan goals.

DIVISION OF ENVIRONMENTAL BIOLOGY (DEB) $144,760,000
+$1,270,000 / 0.9%

DEB Funding
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, DEB	**$138.70**	**$143.49**	**$144.76**	**$1.27**	**0.9%**
Research	**137.01**	**141.79**	**142.74**	**0.95**	**0.7%**
CAREER	4.86	3.97	4.24	0.27	6.8%
Centers Funding (total)	-	-	-	-	N/A
Education	**1.70**	**1.70**	**2.02**	**0.32**	**18.8%**

Totals may not add due to rounding.

DEB supports fundamental research to inventory and document all life on earth; to reveal its evolutionary history and current patterns of speciation and extinction; to understand the origins, maintenance, and consequences of biodiversity; to understand the dynamics of integrated, ecological, and evolutionary processes; and to understand feedbacks between natural and human systems.

DEB encourages research that integrates theoretical, modeling, and empirical approaches and promotes synthesis across spatial, temporal, and phylogenetic scales. Scientific foci in DEB address the processes and patterns of evolution, elucidate the integrated dimensions of biodiversity, address the dynamics of species interactions that govern the assembly of functional communities, and determine the flux of energy and materials through ecosystems. DEB includes support for long term research in evolution, ecology, and ecosystem science. Research supported by DEB is enhanced by interactions with the fields of genomics, organismal biology, computer science, geoscience, synthetic biology, engineering, and mathematics.

In general, 58 percent of the DEB portfolio is available for new research grants. The remaining 42 percent funds continuing grants made in previous years.

FY 2016 Summary

All funding increases represent change over the FY 2015 Estimate.

Research

- In DEB, total support increases slightly (+$950,000) for fundamental research on the interactions and feedbacks of ecological and evolutionary processes in the context of changing environmental factors.
- With the completion of NEON construction and onset of full operations, DEB will encourage and support research that uses NEON data and samples to address macro-scale environmental questions, with funding provided through Emerging Frontiers.
- DEB will increase support for synthetic biology (+$1.0 million), both as an approach to advance understanding of evolutionary ecology processes, and to enable the responsible development of this biotechnology.
- Support for Dimensions of Biodiversity, a SEES program, will continue to be supported in DEB ($11.0 million). In addition, the Dynamics of Coupled Natural Human Systems (CNH) program will

be sustained in DEB. Research supported by these programs contributes to our understanding of ecosystem services, environmental sustainability, and the nexus of food, energy, and water.

- Support for early-career researchers remains a BIO priority; DEB will increase investment (+$270,000, to a total of $4.24 million) in CAREER grants.
- DEB will sustain its FY 2015 investment ($1.90 million) in activities to promote data integration and accessibility in conjunction with a recent program on the genealogy of life, and in coordination with collections and informatics activities in DBI. This innovative program connects an open access tree of life with planetary biodiversity data, specimen/collections data, and with current data streams coming from biodiversity science, phylogenetics, environmental science, paleontology, and geosciences. This integration will foster synthesis, and enable interdisciplinary research in comparative biology.

Education

- DEB will increase support for Research Experiences for Undergraduates (REU) activities by $320,000.

DIVISION OF BIOLOGICAL INFRASTRUCTURE (DBI) $145,410,000 +$2,810,000 / 2.0%

DBI Funding
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
DBI Funding	**$131.81**	**$142.60**	**$145.41**	**$2.81**	**2.0%**
Research	**49.50**	**46.43**	**42.53**	**-3.90**	**-8.4%**
CAREER	4.92	6.00	6.31	0.31	5.2%
Centers Funding (total)	42.75	38.92	34.73	-4.19	-10.8%
Centers for Analysis & Synthesis	21.35	20.80	18.40	-2.40	-11.5%
Nanoscale Science & Engineering Centers	6.33	6.33	6.33	-	-
STC: Center for Microbial Oceanography (C-MORE)	3.32	2.66	-	-2.66	-100.0%
STC: BEACON	5.00	2.50	5.00	2.50	100.0%
STC: Xfel	5.00	5.00	5.00	-	-
Science of Learning Centers	1.75	1.63	-	-1.63	-100.0%
Education	**20.31**	**18.59**	**22.40**	**3.81**	**20.5%**
Infrastructure	**62.00**	**77.59**	**80.48**	**2.89**	**3.7%**
CHESS	5.00	5.00	5.00	-	-
NNCI	-	0.35	0.35	-	-
NNIN	0.35	-	-	-	N/A
Research Resources	56.65	72.24	75.13	2.89	4.0%

Totals may not add due to rounding.

DBI empowers biological discovery by supporting the development and enhancement of biological research resources, human capital, centers, and facilities. In particular, DBI supports the development of, or improvements to: research infrastructure, including instruments, software, and databases; and improvements to biological research collections, living stock collections, and field stations and marine labs. In addition, DBI funds the development of human capital through support of undergraduate, graduate, and postdoctoral research experiences. Support of center, center-like activities, and a few small facilities creates opportunities to address targeted but deep biological questions that have major societal impact.

In general, 30 percent of the DBI portfolio is available for new research grants and 70 percent funds continuing grants made in previous years.

FY 2016 Summary

All funding decreases/increases represent change over the FY 2015 Estimate.

Research

- A significant component of Understanding the Brain (UtB), while supported in EF, focuses on technologies with connections to activities in DBI that include support for student and postdoctoral training in instrumentation, software, and databases.

- Support for centers will decrease $4.19 million to a total of $34.73 million. Support for the Center for Microbial Oceanography: Research and Education (C-MORE) and the Science of Learning Centers ceases in FY 2016; the Plant Science Cyberinfrastructure Collaborative (iPlant) and National Institute for Mathematical and Biological Synthesis (NIMBioS) enter their planned ramp down. Funding for the National Socio-Environmental Synthesis Center (SESync) and funding for the Centers for the Bio/computational Evolution in Action CONsortium (BEACON) are both expected to be renewed.
- Support for early-career researchers is a BIO priority; DBI will increase investment (+$310,000, to a total of $6.31 million) in CAREER grants.

Education

- In FY 2016, support for IUSE will be centralized within DBI ($2.50 million). This activity includes: Partnerships in Undergraduate Learning in Science and Education (PULSE), and Research Collaboration Networks-Undergraduate Biology Education (RCN-UBE).
- The DBI program for Postdoctoral Research Fellowships in Broadening Participation ($2.50 million) aims to promote the advancement of underrepresented groups in STEM at the postdoctoral level, is eager to engage with other NSF initiatives such as INCLUDES.
- DBI will support the new NSF activity, INCLUDES, for $1.40 million to promote the advancement of underrepresented groups in STEM.
- Along with other BIO divisions, DBI increases support for Research Experiences for Undergraduates (REU) activities (+$970,000).
- Support for Postdoctoral Research Fellowships in Biology and Research Coordination Networks will be sustained in FY 2016.

Infrastructure

- Support for biological infrastructure will increase by $2.89 million for a total of $80.48 million, which will enhance support for cyberinfrastructure necessary for 21st century biology, including the development of tools necessary to address grand challenge questions such as understanding the brain.
- DBI will partner with CISE to invest in research that will focus on improving infrastructure for data integration. This is particularly important for integration of different types of data across spatial and temporal scales.
- BIO will increase support for large data-driven science, and, in particular, for CIF21-BioData activities (+$4.64 million for a total of $8.39 million).
- Two facilities will receive sustained funding: the Cornell High Energy Synchrotron Source (CHESS) and the National Nanotechnology Coordinated Infrastructure (NNCI).

DIVISION OF EMERGING FRONTIERS (EF)

$106,140,000
+$9,080,000 / 9.4%

EF Funding
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, EF	**$105.79**	**$97.06**	**$106.14**	**$9.08**	**9.4%**
Research	**70.50**	**56.06**	**61.60**	**5.54**	**9.9%**
CAREER	1.84	1.75	1.75	-	-
Education	**3.40**	**2.55**	**0.05**	**-2.50**	**-98.0%**
Infrastructure	**31.90**	**38.45**	**44.49**	**6.04**	**15.7%**
Research Resources	10.01	0.45	0.45	-	-
National Ecological Observatory Network	21.89	38.00	44.04	6.04	15.9%

Totals may not add due to rounding.

EF identifies, incubates, and supports infrastructure and research areas that transcend scientific disciplines and/or advance the conceptual foundations of biology. It is also responsible for high-risk high-profile projects, such as NEON, that require additional oversight mechanisms. Typically, programs and priority areas begin development in EF and then shift to other BIO divisions to become part of the disciplinary knowledge base. Examples include SEES, which is phasing down, and the Advanced Digitization of Biodiversity Collections (ADBC) program which is transitioning to core divisions. EF also facilitates the development and implementation of new forms of merit review and mechanisms to support transformative research and stimulate creativity. These goals are accomplished by promoting cultural change within and across scientific disciplines to increase and strengthen multidisciplinary collaborations, encourage curiosity and exploration through novel mechanisms and investments, and facilitate support of research areas relevant to all of biology by targeted co-funding throughout the directorate.

In FY 2016, the EF portfolio changes as NEON operations and maintenance (O&M) scales up to support infrastructure following the completion of construction for the observatory, an NSF Major Research Equipment and Facility Construction (MREFC) project. Funds that were previously centralized in EF to support short-term programs will begin to phase down and transition to support this facility as it becomes fully operational. Support for education programs transitioned to DBI core activities in support of undergraduate biology education through IUSE. The research portfolio in EF remains diverse and evolving, as long standing cross-cutting activities transition to core programs (i.e. Dynamics of Coupled Natural and Human Systems (CNH) and ADBC) and new activities are developed. In FY 2016, support will focus on synthetic biology, MacroSystems Biology, early NEON science, and Understanding the Brain (UtB) including the BRAIN Initiative.

In general, 59 percent of the EF portfolio is available for new research grants. The remaining 41 percent funds continuing grants made in previous years.

FY 2016 Summary

All funding increases represent change over the FY 2015 Estimate.

Research

- Research in EF increases by $5.54 million to a total of $61.60 million to enhance support for MacroSystems Biology, early NEON science, and UtB including the BRAIN Initiative.
- Support for synthetic biology (+$2.0 million) will be matched by other BIO divisions (+$1.0 million each in MCB, IOS and DEB) to encourage a cross-disciplinary focus.
- Support for SEES programs in EF will be reduced by $3.50 million to a total of $6.50 million as support for the SEES-CNH focus phases out. Support will continue for Dimensions of Biodiversity.
- CAREER support is maintained at $1.75 million.
- Support for INSPIRE is sustained at $1.0 million.
- Support for BioMaPS within EF will be sustained at $12.64 million and supplemented by support from MCB and IOS as this cross-cutting activity transitions into core programs. In FY 2016, the research focus is expanded to include increasingly essential understanding of environmental impacts, evolutionary consequences, and societal acceptance of synthetic biology products and organisms.
- Support for innovation programs continue with support for new cross-BIO activities, Ideas Labs, and interdisciplinary research.

Education

- In FY 2016, EF will support Career Life Balance (CLB) supplements.

Infrastructure

- Funding for NEON O&M will increase by $6.04 million, to a total of $44.04 million. For more detailed information on NEON, see the MREFC chapter.

DIRECTORATE FOR COMPUTER AND INFORMATION SCIENCE AND ENGINEERING (CISE) $954,410,000 +$32,680,000 / 3.5%

CISE Funding

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Advanced Cyberinfrastructure (ACI)	$211.93	$218.80	$227.29	$8.49	3.9%
Computing and Communication Foundations (CCF)	184.88	191.33	198.59	7.26	3.8%
Computer and Network Systems (CNS)	220.02	227.66	236.32	8.66	3.8%
Information and Intelligent Systems (IIS)	184.87	191.65	198.94	7.29	3.8%
Information Technology Research (ITR)	90.91	92.29	93.27	0.98	1.1%
Total, CISE	**$892.60**	**$921.73**	**$954.41**	**$32.68**	**3.5%**

Totals may not add due to rounding.

About CISE

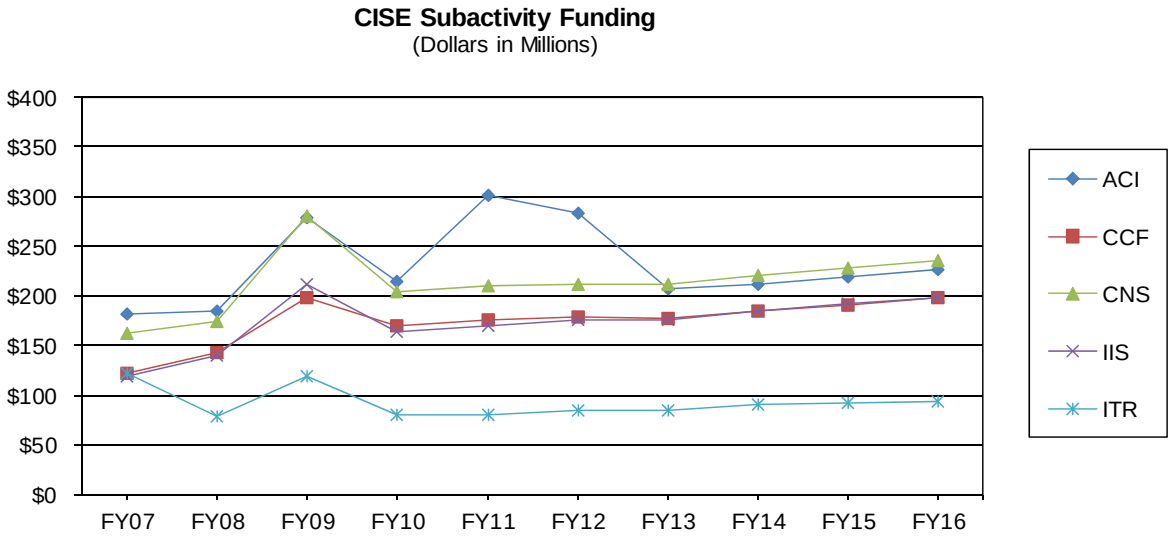
CISE's mission is to promote the progress of computer and information science and engineering research and education, and advance the development and use of cyberinfrastructure; to promote understanding of the principles and uses of advanced computer, communications, and information systems in service to society; and to contribute to universal, transparent, and affordable participation in a knowledge-based society. CISE supports ambitious long-term research and research infrastructure projects within and across the many sub-fields of computing, as well as cyberinfrastructure for all areas of science and engineering; contributes to the education and training of computing professionals; and, more broadly, informs the preparation of a U.S. workforce with computing and computational competencies essential to success in an increasingly competitive global market.

CISE's FY 2016 Budget Request is shaped by the following NSF-wide priorities: Cyber-enabled Materials, Manufacturing, and Smart Systems (CEMMSS), which includes Advanced Manufacturing, Cyber-Physical Systems (CPS), Designing Materials to Revolutionize and Engineer our Future (DMREF), and the National Robotics Initiative (NRI); Clean Energy Technology, which includes Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS); Cyberinfrastructure Framework for 21st Century Science, Engineering, and Education (CIF21); Secure and Trustworthy Cyberspace (SaTC); Risk and Resilience; Understanding the Brain (UtB); NSF Inclusion across the Nation of Communities of Learners that have been Underrepresented for Diversity in Engineering and Science (NSF INCLUDES); NSF Innovation Corps (I-Corps™); and NSF Research Traineeship (NRT). Progress in foundational research and education in these areas is vital to address key national challenges, spur innovation, increase productivity, secure critical infrastructure, improve data analysis and sharing, and develop the next generation of computing and computational scientists.

CISE continues to provide leadership for the multi-agency Subcommittee on Networking and Information Technology Research and Development (NITRD), which is co-chaired by the CISE Assistant Director. All research, education, and research infrastructure projects supported by CISE enrich the agency's NITRD portfolio. As noted by the President's Council of Advisors on Science and Technology (PCAST) in its *Report to the President and Congress - Designing a Digital Future: Federally Funded Research*

and Development in Networking and Information Technology (January 2013),[1] advances in Networking and Information Technology (NIT) are key drivers of U.S. economic competitiveness. Essentially all practical applications of Information Technology are based on ideas and concepts that emerged from investments in basic computing research, driving discovery and innovation in many other areas, e.g., frontiers of scientific research, advanced manufacturing, education and workforce development, health and wellness technologies, sustainability and energy science, transportation, national and homeland security research, and public and private organizational effectiveness and efficiency. These fundamental ideas and concepts have enabled innovative products and applications that now permeate all areas of modern life, positioning NSF and CISE as central and essential actors in improving the Nation's economic outlook and advancing a highly trained, technologically-astute workforce.

CISE provides about 89 percent of the federal funding for basic research at U.S. academic institutions in computer science.



FY 2009 funding reflects both the FY 2009 omnibus appropriation and funding provided through the American Recovery and Reinvestment Act of 2009 (P.L. 111-5).

FY 2016 Summary by Division

- ACI's FY 2016 Budget Request will provide increased data and computational capacity that will allow more researchers and research communities to participate in multi-disciplinary priority areas, such as UtB and INFEWS. ACI will continue to invest in existing programs in computational science, software, data, networking, and cybersecurity. The division also will provide leadership in the NSF-wide CIF21 investment through funding for programs such as Data Infrastructure Building Blocks (DIBBs), Software Infrastructure for Sustained Innovation (SI^2), EarthCube, and Computational- and Data-Enabled Science & Engineering (CDS&E). These investments will include support for Data Science Pilots in partnership with other NSF directorates. ACI will continue to support other cross-disciplinary activities, including transitioning discoveries into practice in the SaTC program, and participating in Risk and Resilience investments. ACI remains responsible for providing national resources and instruments to facilitate collaborations and greater data sharing across research communities. ACI-supported infrastructure will be used to address some of the most difficult and complex research problems in all areas of science and engineering. For example,

[1] www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-nitrd2013.pdf

researchers can take advantage of two significant ACI-supported computational resources that became available in FY 2013: Blue Waters and Stampede.

- CCF's FY 2016 Budget Request is focused on maintaining support for its core programs as well as NSF-wide investments. CCF will continue to support CIF21 through investments in Big Data foundational research, including algorithms and software tools for managing massive amounts of heterogeneous, complex data; new functional capabilities in support of highly parallel computing; and multi-core and multi-machine data management systems. CCF will invest in INFEWS, with a focus on innovative optimization techniques, algorithms, and software development, as part of its support for Clean Energy Technology. CCF will support UtB by investing in the foundational capabilities necessary to integrate computational models across multiple scales. CCF will continue to invest in eXploiting Parallelism and Scalability (XPS) as part of its core programs. CCF will maintain its investment in Algorithms in the Field (AitF), promoting closer collaboration between theoretical computer science researchers and systems and domain experts. CCF will continue to support foundational research in SaTC, including new theories, models, methods, architectures, and tools that aim to achieve security-aware computing, self-healing hardware, and self-protecting software. As part of the National Nanotechnology Initiative (NNI), CCF will focus on foundational research and nanoscale devices and systems, and will invest in the National Nanotechnology Coordinated Infrastructure (NNCI), the successor to the National Nanotechnology Infrastructure Network (NNIN).

- CNS's FY 2016 Budget Request is focused on maintaining support for its core programs as well as NSF-wide investments. CNS will continue to lead the SaTC program in partnership with the Directorates for Education and Human Resources (EHR); Engineering (ENG); Mathematical and Physical Sciences (MPS); and Social, Behavioral, and Economic Sciences (SBE), as well as the other divisions in CISE. CNS will support CEMMSS through leadership of the CPS program in partnership with the Department of Homeland Security (DHS), Department of Transportation (DOT), National Aeronautics and Space Administration (NASA), National Institutes of Health (NIH), ENG, and other CISE divisions. Additionally, CNS will maintain its support for CIF21 through Big Data research on pervasive computing and large-scale data management systems. With EHR and the other CISE divisions, CNS will continue to support the STEM + Computing (STEM + C) Partnerships. CNS will support the development of multidisciplinary urban science, enabling effective integration of networked computing systems, physical devices, data sources, and infrastructure leading to smart cities. CNS will continue its support for mid-scale network infrastructure, including the development of NSFFutureCloud prototypes that provide programmable testbeds for experimenting with novel cloud architectures addressing emerging challenges such as high-confidence systems.

- IIS's FY 2016 Budget Request is focused on maintaining support for its core programs as well as NSF-wide investments. IIS will increase its investments in cognitive science and neuroscience in support of UtB, building on investments in computational neuroscience and foundational research programs to advance understanding of brain functions. IIS will participate in CEMMSS through leadership of NRI, in partnership with four federal agencies (Defense Advanced Research Projects Agency (DARPA), NASA, NIH, U.S. Department of Agriculture (USDA)), three other NSF directorates (ENG, EHR, and SBE), and other CISE divisions. NRI will accelerate the development and use of robots in the U.S. that work beside or cooperatively with people. IIS will participate in CIF21, and will provide leadership in Big Data research activities. This will include funding for new approaches to data mining, machine learning, knowledge extraction, visualization, predictive modeling, and automated discovery. IIS will invest in INFEWS, supporting novel approaches for large-scale data analysis and management. IIS also will continue to lead the joint NSF–NIH Smart and Connected Health (SCH) program, partnering with ENG, SBE, and other CISE divisions. Additionally, with EHR and ENG, IIS will continue to lead the Cyberlearning and Future Learning

Technologies (Cyberlearning) program, which aims to integrate advances in technology with advances in understanding how people learn, with a focus on online learning environments.

- ITR's FY 2016 Budget Request supports emerging high-priority areas of potentially transformative research. Through increased investments in I-Corps™, ITR will build on foundational research and guide the output of scientific discoveries in the development of technologies, products, and processes that benefit society. ITR will continue to invest in the center-scale Expeditions in Computing program. ITR will invest in multi-disciplinary research networks, aiming to build communities across emerging areas of research and education. ITR will increase its investments in multidisciplinary urban science, working with other CISE divisions and ENG and SBE to support effective integration of networked computing systems, physical devices, data sources, and infrastructure leading to smart cities. ITR will continue its investments in mid-scale prototypes for an NSFFutureCloud research infrastructure, extending virtualization beyond the network to large-scale, interconnected computing resources and enabling future cloud and distributed computing experimentation otherwise not possible. Through US Ignite, ITR will continue to integrate cities/regions and advance networking and systems research through experimentation and explorations at scale as well as through research in public-sector gigabit application development and deployment.

Major Investments

CISE Major Investments

(Dollars in Millions)

Area of Investment	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
CAREER	$49.85	$45.50	$47.78	$2.28	5.0%
CEMMSS	85.00	89.00	94.11	5.11	5.7%
Advanced Manufacturing	*39.63*	*41.27*	*43.25*	*1.98*	*4.8%*
Clean Energy Technology	18.00	21.00	22.57	1.57	7.5%
CIF21	85.00	84.21	84.21	-	-
I-Corps™	8.15	11.00	11.65	0.65	5.9%
NSF INCLUDES	-	-	1.78	1.78	N/A
INFEWS	-	-	13.50	13.50	N/A
NRT[1]	1.40	13.38	9.69	-3.69	-27.6%
Risk and Resilience	4.00	6.50	8.00	1.50	23.1%
SaTC	71.18	70.00	70.50	0.50	0.7%
Understanding the Brain	11.58	16.50	28.58	12.08	73.2%
Urban Science	-	1.00	3.50	2.50	250.0%

Major investments may have funding overlap and thus should not be summed.

[1] Outyear commitments for Integrative Graduate Education and Research Traineeship (IGERT) are included in the NRT line and are $1.40 million in FY 2014 and $130,000 in FY 2015.

- CAREER: This program invests in the integration of research and education of early-career researchers and contributes to the development of future generations of computer and information scientists and engineers, as well as computational scientists across all areas of science and engineering.

- CEMMSS: CISE, in partnership with BIO, EHR, ENG, and MPS, aims to establish a scientific basis for engineered systems interdependent with the physical world and social systems, synthesize multi-disciplinary knowledge to model and simulate systems in their full complexity and dynamics, and develop a smart systems technology framework and multidisciplinary urban science. The CPS program, a component of CEMMSS, promises to accelerate advances in 21st-century smart engineered systems, in partnership with four other federal agencies (DHS, DOT, NASA and NIH) and ENG. CEMMSS also includes CISE investments (along with EHR, ENG, and SBE) in NRI (together with DARPA, NASA, NIH, and USDA). As part of this research activity, CISE will synergize investments across multiple research communities and programs in order to transform static systems, processes, and edifices into adaptive, pervasive smart systems with embedded computational intelligence that can sense, adapt, and react.

- Advanced Manufacturing: As part of CEMMSS, CISE, in partnership with ENG and MPS, will invest in research that integrates ubiquitous sensors, computational tools, and highly connected cyber-physical systems in smart processing and cyber manufacturing systems. This investment will result in higher quality products with greater efficiency and sustainability produced by the factories of the future. CISE will also invest in basic research to advance robotics technology, enabling new functionalities and providing the next-generation of products and services in various industries. This includes co-robots that work alongside or cooperatively with people in manufacturing environments to increase their productivity, performance, and safety.

- Clean Energy Technology: CISE will support foundational research in energy-intelligent computing; the development of new theory, algorithms, and design principles to investigate energy versus computation and communication tradeoffs; and the scalability and sustainability of smart energy production software and hardware. CISE research on clean energy is partially supported via investments in INFEWS.

- CIF21: CISE will continue to lead CIF21 through investments in the Big Data, DIBBs, SI^2, EarthCube, and CDS&E programs. Big Data research will focus on core scientific and technological means of managing, analyzing, visualizing, and extracting useful information from large, distributed, and heterogeneous data sets as well as applications in specific research domains. DIBBs aims to develop, implement, and support new cyberinfrastructure to store and manage the diversity, size, and complexity of current and future data sets and streams. To advance new computational infrastructure, SI^2 promises to advance new paradigms and practices in the development and use of robust, reliable, usable, and sustainable software. CISE will increase funding in partnership with other directorates in Data Science Pilots to increase the Nation's capacity in data science.

- I-Corps™: CISE will continue to support I-Corps™ Teams, Sites, and Nodes to further build, utilize, and sustain a national innovation ecosystem that continues to augment the development of technologies, products, and processes that benefit the Nation. CISE's investment will seek to identify NSF-funded researchers who will receive additional support in the forms of mentoring and funding to accelerate innovation that can attract subsequent third-party investment.

- NSF INCLUDES: CISE will participate in NSF INCLUDES, the NSF-wide effort to increase the preparation, participation, advancement, and potential contributions of those who have been traditionally underserved and/or underrepresented in STEM fields.

- INFEWS: CISE will support research in the security and protection of the food-energy-water nexus through investments in new resource management algorithms and architectures; real-time

coordination and communications; robust observation, sensing, and inference; large-scale data analysis and management, including modeling and simulation; and optimization of complex systems. A portion of this funding will be directed toward Advanced Computational Infrastructure, providing additional resources in support of research on INFEWS.

- NSF Research Traineeship (NRT): CISE will continue to fund STEM graduate students in interdisciplinary areas of national priority, and to support the development of transformative and scalable models for STEM graduate education. CISE funding for FY 2015 Estimate includes funding to support awards that could not be made during FY 2014.

- Risk and Resilience: In partnership with ENG and SBE, CISE supports the science and engineering necessary to enable advances in large-scale resilient and interdependent infrastructures.

- SaTC: NSF continues to align its cybersecurity investments (including investments from EHR, ENG, MPS, and SBE) with the national cybersecurity strategy, *Trustworthy Cyberspace: Strategic Plan for the Federal Cybersecurity Research and Development Program.*[2] SaTC aims to support scientific foundations, induce change, maximize research impact, and accelerate the transition of advances to practice. CISE is collaborating with EHR to support cyber-secure workforce development to enable a growing pipeline of researchers and educators, and to develop a citizenry that understands the security and privacy of the digital systems on which society depends. This investment also includes support for the Comprehensive National Cybersecurity Initiative (CNCI) ($48.0 million).[3]

- Understanding the Brain: In collaboration with other NSF directorates and offices, CISE will support projects focused on understanding the brain. In particular, CISE will support projects that develop computational approaches for investigating neural and behavioral plasticity in response to external changes. CISE investments will enable the research needed to integrate computational models across scales; the development of innovative neurotechnologies to monitor brain function; and the expansion of the capacity of neuroscience infrastructure to integrate data across levels of analysis from molecular to behavioral scales. A portion of this funding will be directed toward Advanced Computational Infrastructure, providing additional resources in support of research on Understanding the Brain.

- Urban Science: In collaboration with ENG and SBE, CISE will support a new NSF-wide multidisciplinary activity in urban science. This investment will focus on the research and development of critical infrastructure and applications, which address pressing urban challenges, such as sustainability, livability, and equity, through both fundamental research and translational research that is supported via partnerships. Multidisciplinary urban science research efforts at NSF will address the question of how cities can be intelligently and effectively designed, adapted, and managed to maximize their positive potential. Support for urban sciences will enable the integration of networked computing systems, physical devices, data sources, and infrastructure leading to smart cities.

[2] www.whitehouse.gov/sites/default/files/microsites/ostp/fed_cybersecurity_rd_strategic_plan_2011.pdf
[3] www.whitehouse.gov/issues/foreign-policy/cybersecurity/national-initiative

CISE Funding for Centers Programs and Facilities

CISE Funding for Centers Programs

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, Centers Programs	**$10.00**	**$10.00**	**$10.00**	**-**	**-**
STC: The Center for Science of Information (CCF)	5.00	5.00	5.00	-	-
STC: The Center for Brains, Minds and Machines (CCF, IIS, ITR)	5.00	5.00	5.00	-	-

Totals may not add due to rounding.

For detailed information on individual centers, please see the NSF-wide Investments chapter.

- CISE will provide the sixth year of funding for the STC Center for Science of Information at Purdue University. The goal of this center is to develop a new science of information, incorporating common features associated with data/information, such as space, time, structure, semantics, and context, but which are not addressed by earlier mathematical theories, e.g., data obfuscation and hiding techniques. This new science of information will enhance robustness and the principles of redundancy and fault tolerance found in natural systems.

- CISE will provide the fourth year of funding for the STC Center for Brains, Minds and Machines: The Science and the Technology for Intelligence at MIT. This center has five main research themes: circuits for intelligence; the development of intelligence in children; social intelligence; the integration of visual, motor, language, and social intelligence; and theoretical aspects of intelligence.

CISE Funding for Facilities

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, Facilities	**$0.60**	**$0.60**	**$0.60**	**-**	**-**
National Nanotechnology Infrastructure Network (CCF)	0.60	-	-	-	N/A
National Nanotechnology Coordinated Infrastructure (CCF)	-	0.60	0.60	-	-

Totals may not add due to rounding.

For detailed information on individual facilities, please see the Facilities chapter.

Summary and Funding Profile

CISE supports investments in core and interdisciplinary research and education, as well as in computing research infrastructure.

In FY 2016, the number of research grant proposals is expected to increase by approximately 7.7 percent compared to the FY 2015 Estimate. CISE expects to award approximately 1,640 research grants in FY 2016. Average annualized award size and average award duration are expected to remain constant between the FY 2015 Estimate and FY 2016 Estimate.

Funding for research infrastructure represents 17.6 percent of the CISE Request. Most of CISE's research infrastructure support is for High Performance Computing (HPC) (see Appendix A for more information on the HPC portfolio).

CISE Funding Profile

	FY 2014 Actual Estimate	FY 2015 Estimate	FY 2016 Estimate
Statistics for Competitive Awards:			
Number of Proposals	7,436	7,800	8,400
Number of New Awards	1,682	1,820	1,970
Funding Rate	23%	23%	23%
Statistics for Research Grants:			
Number of Research Grant Proposals	7,094	7,440	8,010
Number of Research Grants	1,407	1,520	1,640
Funding Rate	20%	20%	20%
Median Annualized Award Size	$166,122	$165,000	$165,000
Average Annualized Award Size	$199,367	$210,000	$210,000
Average Award Duration, in years	2.9	3.0	3.0

Program Monitoring and Evaluation

Committees of Visitors (COV)

- In early FY 2015, CISE convened a Committee of Visitors (COV) to examine and assess the quality of the merit review process across three of its divisions – CCF, CNS, and IIS. The CISE Advisory Committee subsequently accepted the COV report. CISE is not holding any COVs in FY 2016.

Science and Technology Policy Institute (STPI) Reports and Evaluations

- In FY 2012, the Science and Technology Policy Institute (STPI) was tasked to conduct program evaluation feasibility studies for the SaTC and CEMMSS programs. These feasibility studies are providing methods for examining baseline portfolio investments and identifying metrics to measure progress toward program goals. They are part of a broader effort to develop a plan for impact assessments of SaTC and CEMMSS investments. The preliminary work to identify baseline evaluation metrics was conducted in FY 2013 – FY 2014, and it is anticipated that further program evaluation analyses will continue in FY 2016. Yearly program-wide analyses will be presented to the CEMMSS and SaTC working groups and to NSF senior management.

STEM Evaluation

- Evaluation is also a vital part of CISE's STEM education programs. Each of the STEM + C Partnerships projects managed by CISE has a rigorous research and/or evaluation plan designed to guide project progress and measure its impact. These plans include descriptions of the instruments and metrics that are to be used. Across the STEM + C Partnerships portfolio managed by CISE, a set of common metrics and a design for evaluation instruments are being developed. The initial design is complete, and the first program evaluation is expected to be under contract by FY 2016.

Reports

- CISE funded the National Academy of Sciences (NAS) Computer Science and Telecommunications Board (CSTB) to study the IT innovation ecosystem and to assess the long-term economic impacts of CISE investments. The report, *Assessing the Impacts of Changes in the Information Technology R&D Ecosystem,*[4] published in 2009, includes an in-depth articulation of the creation of almost 20 IT industries, since 1965, valued at a minimum of a billion dollars each. To update this study, CISE funded CSTB to identify recent IT industries that have reached the billion dollar mark; develop a brief report that highlights the updated figures; and summarize results-to-date of IT research, including the nature and successes of U.S. research partnerships among government, industry, and universities, and the economic payoffs of these research investments. The resulting report, *Continuing Innovation in Information Technology,* was published in 2012.[5] The framework in the report is being employed as part of a current CSTB study, *Continuing Innovation in Information Technology: A Workshop* (described below).
- In FY 2012, a CSTB study, *The Future of Computing Performance: Game Over or Next Level?,*[6] together with a white paper from the CISE-funded Computing Community Consortium (CCC), *21st Century Computer Architecture,*[7] outlined the need for advances in computer architecture research which led to the development of the XPS program that was initiated in FY 2013.
- In FY 2013, the CCC collected community white papers articulating the potential needs and payoff for additional investments in mid-scale infrastructure for computing research[8] which led to the development of the NSFFutureCloud program started in FY 2014.
- In FY 2014 through FY 2015, the CCC led a Computing Visions 2025 initiative, intended to inspire the computing community to envision future trends and opportunities in computing research. Two workshops were held under this initiative: *Interacting with Computers All Around Us*, and *The New Making Renaissance: Programmable Matter and Things.* These workshops have the potential to influence the development of CISE programs in FY 2016. In addition, two other ongoing workshop activities led by the CCC are contributing to an understanding of the role of IT in home management of chronic diseases, and in opportunities at the intersection of computer science and brain science.
- CISE also funded four CSTB studies that are currently ongoing and have the potential to influence the development of CISE programs in FY 2016.
    - *Continuing Innovation in Information Technology: A Workshop:* will conduct a public workshop that highlights additional examples of the impacts of computing research using the framework established in the "tiretracks" figure published in CSTB's 2012 report *Continuing Innovation in Information Technology* and explore further uses of the figure and framework.
    - *A Primer on Cybersecurity: Leveraging Two Decades of National Academies Work*: will examine what is known about effective technical and nontechnical approaches, the state of the art and open challenges, why relatively little progress has been made in cybersecurity despite the recommendations of many reports from the Academies and elsewhere, and potential policy

[4] www.nap.edu/catalog.php?record_id=12174
[5] www.nap.edu/catalog.php?record_id=13427
[6] www.nap.edu/openbook.php?record_id=12980
[7] http://cra.org/ccc/docs/init/21stcenturyarchitecturewhitepaper.pdf
[8] http://cra.org/ccc/visioning/visioning-activities/mid-scale-infrastructure-investments-for-computing-research

responses.

- *Toward 21st-Century Cyber-Physical Systems Education*: will conduct a study on the current and future needs in education for cyber-physical systems (CPS) and articulate a vision for a 21st century CPS-capable U.S. workforce.
- *Future Directions for NSF Advanced Computing Infrastructure to support U.S. Science in 2017-2020:* will examine anticipated priorities and associated tradeoffs for advanced computing in support of NSF-sponsored science and engineering research.

The Performance chapter provides details regarding the periodic reviews of programs and portfolios of programs by external Committees of Visitors and directorate Advisory Committees. Please see this chapter for additional information.

Number of People Involved in CISE Activities

	FY 2014 Actual Estimate	FY 2015 Estimate	FY 2016 Estimate
Senior Researchers	6,663	6,900	7,100
Other Professionals	1,123	1,200	1,200
Postdoctorates	491	500	500
Graduate Students	6,064	6,300	6,500
Undergraduate Students	2,433	2,500	2,600
Total Number of People	**16,774**	**17,400**	**17,900**

DIVISION OF ADVANCED CYBERINFRASTRUCTURE (ACI) $227,290,000
+$8,490,000 / 3.9%

ACI Funding
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, ACI	**$211.93**	**$218.80**	**$227.29**	**$8.49**	**3.9%**
Research	**79.56**	**96.30**	**97.79**	**1.49**	**1.5%**
CAREER	3.02	3.10	3.30	0.20	6.5%
Education	**4.83**	**8.70**	**5.70**	**-3.00**	**-34.5%**
Infrastructure	**127.53**	**113.80**	**123.80**	**10.00**	**8.8%**
Networking and Computational Resources Infrastructure and Services	127.53	113.80	123.80	10.00	8.8%

Totals may not add due to rounding.

ACI supports the advance of science and engineering research and education by exploring, developing, creating, and supporting secure, advanced, and global cyberinfrastructure (CI). ACI partners with other CISE divisions and NSF directorates and offices to support research and development across the entire range of cyberinfrastructure activities required to advance scientific and engineering frontiers. This includes the acquisition, integration, coordination, and operations associated with data, networking, computation, software, and the development of CDS&E tools and expertise. ACI focuses on the development of these resources and capabilities, as well as on the expertise to conduct next-generation science and engineering, in order to address complex and multidisciplinary discovery, prediction, and innovation. ACI provides computational support to more than 8,000 faculty and researchers, and supports international activities in networking, software, data, and computation, including connectivity to major international resources and scientific instruments. ACI also fosters relationships with other federal agencies and international research funding agencies with shared scientific priorities to promote collaborative research cyberinfrastructure.

In general, 41 percent of the ACI portfolio is available for new grants and 59 percent is available for continuing grants.

Approximately 60 percent of ACI's budget is used to support individuals and small groups of researchers. The remaining 40 percent of the budget goes toward the support of larger cyberinfrastructure consortia, including the eXtreme Digital (XD) services program, the Blue Waters Petascale Computing Program, and mid-scale pilots and prototypes toward an integrated data infrastructure.

FY 2016 Summary

All funding decreases/increases represent change over the FY 2015 Estimate.

Research

- ACI will continue to support early-career researchers through increased investments in the CAREER program (+$200,000 to a total of $3.30 million).

- In partnership with ENG, GEO, MPS, SBE, and other CISE divisions, ACI will continue to enable advances in large-scale resilient, secure, and interoperable research cyberinfrastructure through the Risk and Resilience investment area (+$500,000, to a total of $3.0 million).
- ACI will invest in the NSF-wide priority area INFEWS (+$500,000 to a total of $500,000), as part of increased support for Clean Energy Technology (+$100,000 to a total of $3.60 million). ACI will focus on the exploration of new robust, integrative approaches to sustainable software and data cyberinfrastructure to advance multidisciplinary computational and data science for food, water, and energy security research and education.
- ACI will continue to provide leadership for CIF21 ($62.71 million). This leadership includes developing coordinated CIF21 programs and solicitations, and identifying common approaches for a scalable, comprehensive cyberinfrastructure. ACI will invest in multidisciplinary data and software programs, such as CDS&E, EarthCube, SI^2, and DIBBS, including Data Science Pilots that will be undertaken in partnership with other NSF directorates.

Education

- ACI will continue support for the NSF Research Traineeship program (-$2.50 million to a total of $3.0 million) to encourage the development of bold, new, potentially transformative, and scalable models for STEM graduate training focusing on areas of national priority.
- ACI will maintain its investments in the STEM + C Partnerships ($500,000), which seek to enhance computational competencies for students and teachers.
- Along with the other CISE divisions, ACI will maintain support for REU sites and supplements ($1.20 million).

Infrastructure

- ACI will increase its data and computational capacity (+$10.0 million to a total of $123.80 million) to support multidisciplinary research in NSF priority areas, including INFEWS and UtB. The need for increased data and computational capacity is driven by the growing set of collaborative, multidisciplinary research teams and communities as well as the growth of both simulations and data analytics for scientific discovery. The following investments are part of ACI's support for Networking and Computational Resources Infrastructure and Services:
  - Advanced computing investment (+$6.0 million to a total of $80.65 million). This will include the combined services and resources of XD, operating a virtual computational environment for more than 8,000 scientists and engineers, and the Blue Waters sustained petascale resource that allows computational scientists in a variety of domains, such as molecular dynamics, protein folding, cosmology, climate modeling, and earthquake modeling, to retain international competitiveness by addressing some of the most difficult research problems known today (see Appendix A for more information on the HPC portfolio).
  - Investments in transition to practice within SaTC ($3.0 million). Advanced, secure networking and data sharing are increasingly important to support research collaborations and facilitate multidisciplinary research and education.

DIVISION OF COMPUTING AND COMMUNICATION FOUNDATIONS (CCF) — $198,590,000 / +$7,260,000 / 3.8%

CCF Funding
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, CCF	**$184.88**	**$191.33**	**$198.59**	**$7.26**	**3.8%**
Research	**174.22**	**180.13**	**188.39**	**8.26**	**4.6%**
CAREER	13.97	13.67	14.36	0.69	5.0%
Centers Funding (total)	9.00	8.00	8.00	-	-
STC: The Center for Science of Information	5.00	5.00	5.00	-	-
STC: The Center for Brains, Minds and Machines	4.00	3.00	3.00	-	-
Education	**10.06**	**10.60**	**9.60**	**-1.00**	**-9.4%**
Infrastructure	**0.60**	**0.60**	**0.60**	**-**	**-**
National Nanotechnology Coordinated Infrastructure (NNCI)	-	0.60	0.60	-	-
National Nanotechnology Infrastructure Network (NNIN)	0.60	-	-	-	N/A

Totals may not add due to rounding.

CCF supports research and education activities that explore the foundations and limits of computation, communication, and information; advance algorithmic knowledge for research areas both within and outside computer science; and advance software, hardware, and computer system design. CCF's research investments support advances in the design and analysis of algorithms; computational complexity, theoretical and experimental studies of algorithms and their resource requirements; and formal models of computation. These research investments include models for parallel, distributed, and heterogeneous multi-core machines. CCF invests in research addressing the theoretical underpinnings and enabling technologies for information acquisition, transmission, and processing in communication and information networks, such as sensor, wireless, multimedia, and biological networks. CCF investments advance the design, verification, evaluation, and utilization of computing hardware and software through new theories and tools that focus on performance, correctness, usability, dependability, reliability, and scalability. CCF also invests in research that explores the potential impact of emerging technologies on computation and communication, including nanotechnology, biotechnology, and quantum devices and systems.

In general, 76 percent of the CCF portfolio is available for new research grants and 24 percent is available for continuing grants.

FY 2016 Summary

All funding decreases/increases represent change over the FY 2015 Estimate.

Research

- CCF will continue to support early-career researchers through increased investments in the CAREER program (+$690,000 to a total of $14.36 million).

- CCF will invest in the NSF-wide priority area INFEWS (+$3.50 million to a total of $3.50 million), as part of increased support for Clean Energy Technology (+$720,000 to a total of $11.72 million). CCF will focus on foundational research in energy-intelligent computing, leading to novel approaches for large-scale data analysis and management; and innovative optimization techniques, algorithms and software development.
- CCF will increase its investments in the NSF-wide priority area UtB (+$2.50 million to a total of $8.25 million) through investments in core and crosscutting research, including integrating computational models across multiple scales, from molecules to systems, toward accomplishing the ultimate goal of establishing an integrative, quantitative, and predictive theory of brain function.
- CCF will continue to support the NSF-wide CEMMSS program through CPS ($5.50 million) and NRI ($3.0 million). This investment will emphasize development of new methods for specification and verification of software and hardware systems useful for various sectors including cyber manufacturing.
- CCF will maintain its current level of support for SaTC ($14.25 million) through investments in theories, models, algorithms, architectures, languages and tools for increased security, privacy and trust, as well as in new cryptographic approaches for hardware assurance.
- CCF will continue to support CIF21 ($8.25 million). CCF will emphasize its investments in Big Data foundational research, including algorithms and software tools for handling large and heterogeneous data sets; randomized streaming algorithms, which are scalable and extremely efficient for Big Data; methods for validating data; and tools for extracting knowledge to enable new discoveries.
- CCF will maintain its current investment level of support for the Algorithms in the Field (AitF) program ($4.0 million). The AitF program promotes closer collaboration between theoretical computer science researchers, who focus on the design and analysis of provably efficient and correct algorithms, and applied researchers, including systems and domain experts.
- CCF will maintain the current investment level of support for the XPS program ($6.50 million). Through XPS, CCF supports research into new and visionary approaches to re-evaluate and possibly re-design the traditional computer hardware and software stack for today's heterogeneous parallel, concurrent, and distributed systems, and investigates new holistic approaches to parallelism and cross-layer design.
- CCF will continue to support two STCs, the Center for Science of Information at Purdue University ($5.0 million) and the Center for Brains, Minds and Machines: The Science and the Technology of Intelligence at MIT ($3.0 million). The CISE investment in the MIT Center ($5.0 million) is shared with the IIS and ITR divisions.

Education

- CCF will continue to support the NSF Research Traineeship program (-$1.0 million to a total of $1.50 million) to encourage the development of bold, new, potentially transformative, and scalable models for STEM graduate training focusing on areas of national priority.
- CCF will maintain its investments in the STEM + C Partnerships ($4.0 million), which seek to enhance computational competencies for students and teachers.
- Along with the other CISE divisions, CCF will maintain support for REU sites and supplements ($3.25 million).

Infrastructure

- CCF will fund the National Nanotechnology Coordinated Infrastructure (NNCI) ($600,000), supported primarily by ENG. NNCI is the successor to the National Nanotechnology Infrastructure Network (NNIN).

DIVISION OF COMPUTER AND NETWORK SYSTEMS (CNS) $236,320,000
+$8,660,000 / 3.8%

CNS Funding

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, CNS	**$220.02**	**$227.66**	**$236.32**	**$8.66**	**3.8%**
Research	**176.83**	**181.70**	**192.05**	**10.35**	**5.7%**
CAREER	12.29	13.33	14.01	0.68	5.1%
Education	**15.57**	**15.96**	**14.27**	**-1.69**	**-10.6%**
Infrastructure	**27.61**	**30.00**	**30.00**	**-**	**-**
Research Resources	27.61	30.00	30.00	-	-

Totals may not add due to rounding.

CNS supports research and education activities that advance understanding of the fundamental properties of computer systems and networks; explore new ways to make better use of existing computer systems and networks; and develop novel paradigms, abstractions, and tools for designing, analyzing, and building next-generation computer systems and networks that are robust, secure, and trustworthy. CNS investments include, but are not limited to, cyber-physical, embedded, cloud computing, wearable, and "smart dust" systems. CNS investments in fundamental network research create new insights into the dynamics of complex networks, and explore new architectures for future-generation networks and services. CNS provides scientific leadership in cybersecurity, supporting research and education activities that will ensure society's ubiquitous computing and communications systems deliver the quality of service they are designed to achieve without disruption, while enabling and preserving privacy, security, and trust. CNS also plays a leadership role in coordinating CISE investments in research infrastructure resources and in the development of the computing workforce of the future.

In general, 65 percent of the CNS portfolio is available for new grants and 35 percent is available for continuing grants.

FY 2016 Summary

All funding decreases/increases represent change over the FY 2015 Estimate.

Research

- CNS will continue to support early-career researchers through increased investments in the CAREER program (+$680,000 to a total of $14.01 million).
- In partnership with EHR, ENG, MPS, SBE, and the other CISE divisions, CNS will continue to lead SaTC (+$500,000 to a total of $44.30 million), which aligns with the Comprehensive National Cybersecurity Initiative (CNCI). Through SaTC, CNS will invest in areas of current critical importance such as network and cloud security, cybereconomics, and science of security and of privacy. These investments also will address education and workforce issues related to cybersecurity.
- In partnership with four other federal agencies (DHS, DOT, NASA, and NIH), ENG, and other CISE divisions, CNS will continue to lead the CPS program ($23.0 million). As a critical underpinning of CEMMSS, CNS will support foundational interdisciplinary research and education in adaptive and pervasive smart systems such as cyber manufacturing, smart grid technologies, and medical devices. CNS will also continue its investments in NRI ($4.50 million).

- CNS will participate in the NSF-wide investment INFEWS (+$3.25 million to a total of $3.25 million), as part of increased support for clean energy technology (+$500,000 to a total of $4.50 million). CNS will focus its support on foundational systems research in energy-intelligent computing, leading to novel approaches for robust observation, sensing, and inference. CNS will also invest in research related to control, automation, and optimization of the complex systems underlying the nexus of food, energy, and water.
- In partnership with ENG, GEO, MPS, SBE, and other CISE divisions, CNS will continue to support the science and engineering needed to enable advances in large-scale resilient and interdependent infrastructures through the Risk and Resilience investment area (+$1.0 million to a total of $5.0 million).
- CNS will support the NSF-wide priority area UtB ($1.5 million) by investing in core and crosscutting research in neurotechnology development, as well as in building innovative pilot infrastructure and analytic tools for data integration across scales and disciplines.
- In partnership with ENG, SBE, and other CISE divisions, CNS will support activities focused on multidisciplinary urban science (+$2.0 million to a total of $2.50 million), enabling effective integration of networked computing systems, data sources, and infrastructure underlying smart cities.
- CNS will continue to support CIF21 ($3.75 million) through investments in foundational systems research advancing the science of big data, including middleware, tools, and networking support for managing massive amounts of heterogeneous, complex, and real-time data.
- CNS will continue investing in US Ignite ($2.50 million) by developing innovative public-sector gigabit applications that leverage or enhance advanced networking technologies in support of national priority areas.

Education

- CNS will invest in NSF INCLUDES (+$1.0 million to a total of $1.0 million) to increase the preparation, participation, advancement, and potential contributions of those who have been traditionally underserved and/or underrepresented in STEM.
- CNS will maintain its investments in the STEM + C Partnerships, which seek to enhance computational competencies for all students ($4.0 million). This program will enlarge the pool of K-14 students and teachers who develop and practice computational competencies in a variety of contexts, as well as the pool of early postsecondary students who are engaged and have the background in computing necessary to successfully pursue degrees in computing-related and computationally-intensive fields of study.
- Along with the other CISE divisions, CNS will maintain support for REU sites and supplements ($4.48 million).
- CNS will continue to support the NSF Research Traineeship program (-$690,000 to a total of $990,000) to encourage the development of bold, new, potentially transformative, and scalable models for STEM graduate training focusing on areas of national priority.

Infrastructure

- Through the CISE Research Infrastructure (CRI) program ($18.0 million), CNS supports acquisition, enhancement, community access, and operation of state-of-the-art computing research infrastructure enabling high-quality computing research and education across a diverse range of institutions.
- CNS will maintain support for the development of world-class, mid-scale network infrastructure ($9.50 million), including NSFFutureCloud, providing programmable testbeds for experimenting with novel cloud architectures addressing emerging challenges such as high-confidence systems.
  CNS will continue to support US Ignite ($2.50 million) to integrate additional U.S. cities/regions and create a unique at-scale infrastructure, enabling multi-city/regional testbeds and “Living Labs” that facilitate building and experimenting with advanced public-sector gigabit networking applications that address national priorities.

DIVISION OF INFORMATION AND INTELLIGENT SYSTEMS (IIS) — $198,940,000 +$7,290,000 / 3.8%

IIS Funding

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, IIS	**$184.87**	**$191.65**	**$198.94**	**$7.29**	**3.8%**
Research	**173.72**	**181.85**	**189.14**	**7.29**	**4.0%**
CAREER	20.11	15.40	16.11	0.71	4.6%
Centers Funding (total)	-	1.00	1.00	-	-
STC: The Center for Brains, Minds and Machines	-	1.00	1.00	-	-
Education	**11.15**	**9.80**	**9.80**	**-**	**-**

Totals may not add due to rounding.

IIS supports research and education to develop and apply new IT to enhance the capabilities of people and machines to create, discover, and reason by advancing their ability to represent, collect, store, organize, visualize, and communicate data and information; to develop new knowledge to support people in the design and use of IT; and to advance knowledge about how computational systems can perform tasks autonomously, robustly, and flexibly.

IIS research investments support the exploration of novel theories and innovative technologies that advance understanding of the complex and increasingly coupled relationships between people and computing, and promise to enhance quality of life. Investments in information integration and informatics focus on the processes and technologies involved in creating, managing, visualizing, and fusing diverse data, information, and knowledge from disparate and uncoordinated sources within a changing landscape of computing platforms, from personal devices to globally-distributed networks. IIS also invests in research on artificial intelligence, computer vision, natural language, robotics, machine learning, computational neuroscience, cognitive science, and areas leading to the computational understanding and modeling of intelligence in complex, realistic contexts. These investments aim to revolutionize understanding of brain functions.

In general, 71 percent of the IIS portfolio is available for new research grants and 29 percent is available for continuing grants.

FY 2016 Summary

All funding decreases/increases represent change over the FY 2015 Estimate.

Research

- IIS will continue to support early-career researchers through increased investments in the CAREER program (+$710,000 to a total of $16.11 million).
- IIS will increase its investments in the NSF-wide priority area UtB (+$4.58 million to a total of $13.83 million) by supporting core and crosscutting research in developing novel computational tools for performing multi-scale analysis of physiological, cognitive, and behavioral data, and innovative models that will accelerate the integration of knowledge across scales from molecules to systems and across multiple disciplines. This research aims to accelerate the formulation of an integrative, quantitative, and predictive theory of brain function.

- IIS will participate in the NSF-wide investment INFEWS (+$1.25 million to a total of $1.25 million), as part of increased support for clean energy technology (+$250,000 to a total of $2.75 million). IIS will focus on novel approaches for large-scale data analysis and management will bring together multidisciplinary researchers, particularly in real-time data analytics and artificial intelligence.
- IIS will continue to support the NSF-wide investment CEMMSS. In partnership with four other federal agencies (DARPA, NASA, NIH, and USDA), three other NSF directorates (ENG, SBE, and EHR), and other CISE divisions, IIS will continue to lead the NRI program ($13.0 million). NRI, a component of CEMMSS, focuses on human-centered research in developing service robots; this requires significant advances in human-robot interaction. Application domains include robots as co-workers in advanced manufacturing environments, aides supporting emergency responders in the field, and service robots assisting the elderly to live independently. IIS will also focus on fundamental research in robotics, including advanced sensing, control, and power sources; integrated problem-solving architectures and decision algorithms; and safe and soft structures. As part of its CEMMSS investment, IIS will also continue its investments in CPS ($4.50 million).
- IIS will continue to invest in CIF21 ($9.50 million). In partnership with other NSF directorates and CISE divisions, IIS will lead Big Data research activities to address challenges in the management of data and knowledge, to devise computational methods for data analysis, and to automate many aspects of data-enabled discovery processes, while ensuring appropriate security and privacy guarantees.
- In partnership with six NIH institutes, ENG, SBE, and other CISE divisions, IIS will continue to lead the Smart and Connected Health program ($9.0 million). IIS will pursue improvements in safe, effective, efficient, and patient-centered proactive and predictive health and wellness technologies. This program addresses changing age demographics with investments in assistive, engineered cyber-physical systems.
- IIS will continue to lead the Cyberlearning program ($9.75 million) with EHR, ENG and other CISE divisions. This activity will integrate advances in technology with advances in the ways people learn; resolve how to more effectively use technology for promoting learning; and design new technologies for integration in learning environments and evaluate their use. Interdisciplinary teams will study the deluge of data produced from new on-line teaching paradigms to better understand learning mechanisms and enable productive, personalized, customized, and privacy-preserving education.
- As part of its investment in SaTC ($8.95 million), IIS will continue to support research in cyber-security and privacy, with an emphasis on data science, usability, socio-technical, and human-centered approaches.
- IIS will provide support for the STC Center for Brains, Minds and Machines: The Science and the Technology of Intelligence at MIT ($1.0 million) along with the CCF and ITR divisions.

Education

- IIS will continue support for the NSF Research Traineeship program ($1.0 million) to encourage the development of bold, new, potentially transformative, and scalable models for STEM graduate training focusing on areas of national priority.
- IIS will maintain its investments in the STEM + C Partnerships ($4.0 million), which seek to enhance computational competencies for students and teachers.
- Along with the other CISE divisions, IIS will maintain support for REU sites and supplements ($3.95 million).

DIVISION OF INFORMATION TECHNOLOGY RESEARCH (ITR) — $93,270,000 / +$980,000 / 1.1%

ITR Funding

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, ITR	**$90.91**	**$92.29**	**$93.27**	**$0.98**	**1.1%**
Research	**79.16**	**75.84**	**75.54**	**-0.30**	**-0.4%**
CAREER	0.46	-	-	-	N/A
Centers Funding (total)	-	1.00	1.00	-	-
STC: The Center for Brains, Minds and Machines	-	1.00	1.00	-	-
Education	**0.13**	**2.95**	**4.23**	**1.28**	**43.4%**
Infrastructure	**11.62**	**13.50**	**13.50**	**-**	**-**
Research Resources	11.62	13.50	13.50	-	-

Totals may not add due to rounding.

ITR provides support for transformative explorations in computer and information science and engineering research, infrastructure, and related education activities, emphasizing the funding of high-risk, multi-investigator, and multidisciplinary projects.

In general, 40 percent of the ITR portfolio is available for new grants and 60 percent is available for continuing grants.

FY 2016 Summary

All funding decreases/increases represent change over the FY 2015 Estimate.

Research

- Through I-Corps™ (+$650,000 to a total of $11.65 million), ITR will invest in NSF-funded researchers who will receive additional support – in the form of mentoring and funding – to accelerate innovation and transfer of knowledge from lab to practice. ITR will also invest in I-Corps™ Sites and Nodes to further build, utilize, and sustain a national innovation ecosystem that continues to augment the development of technologies, products, and processes that benefit the Nation.
- In partnership with ENG, SBE, and other CISE divisions, ITR will support activities focused on multidisciplinary urban science (+$500,000 to a total of $1.0 million), enabling effective integration of networked computing systems, physical devices, data sources, and infrastructure that leads to smart cities.
- ITR will continue its investment in US Ignite ($2.50 million) by developing innovative public-sector gigabit applications that leverage or enhance advanced networking technologies in support of national priority areas.
- In collaboration with ENG, CISE will maintain support for innovative partnerships and collaborations between universities and industries, in part through the Industry/University Cooperative Research Centers (I/UCRC) program, which will continue to establish centers that partner industry with university research efforts ($8.0 million).

- ITR will maintain its investments in the center-scale Expeditions in Computing program ($12.0 million). This program identifies projects with transformative research agendas that promise to accelerate discovery at the frontiers of computing and communication.
- ITR will invest in multi-disciplinary research networks, including support for the Science Across Virtual Institutes (SAVI) activity ($2.0 million). These research networks will provide opportunities to develop collaborations in areas of emerging interest to computer and information science and engineering, including international partnerships.
- ITR will continue to provide support for emerging and urgent high-priority areas of potentially transformative research through various award mechanisms, such as EArly-concept Grants for Exploratory Research (EAGERs) and Grants for Rapid Response Research (RAPIDs), and through co-funding of awards with other NSF directorates to pursue important emerging areas.
- ITR will maintain support ($1.0 million) for the STC Center for Brains, Minds and Machines: The Science and the Technology of Intelligence at MIT along with the CCF and IIS divisions.

Education

- ITR will continue support for the NSF Research Traineeship program (+$500,000 to a total of $3.20 million) to encourage the development of bold, new, potentially transformative, and scalable models for STEM graduate training focusing on areas of national priority.
- ITR will invest in NSF INCLUDES (+$780,000 to a total of $780,000) to increase the preparation, participation, advancement, and potential contributions of those who have been traditionally underserved and/or underrepresented in STEM.

Infrastructure

- ITR will continue to support US Ignite ($2.50 million) to integrate additional U.S. cities/regions and create a unique at-scale infrastructure, enabling multi-city/regional testbeds and "Living Labs" that facilitate building and experimenting with advanced public-sector gigabit networking applications that address national priorities.
- ITR will extend virtualization beyond the network to large-scale, interconnected computing resources by continuing to develop mid-scale prototypes for an NSFFutureCloud research infrastructure, providing programmable testbeds for experimenting with novel cloud architectures addressing emerging challenges such as high-confidence systems ($6.0 million).

APPENDIX A – HIGH PERFORMANCE COMPUTING PORTFOLIO

High Performance Computing Funding

(Dollars in Millions)

	Total of Prior Years	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
Petascale (Track 1)	$299.64	$55.38	$21.65	$28.65
Innovative HPC Program	213.38	27.79	30.00	25.00
Teragrid - Phase III (XD)	142.54	13.55	23.00	27.00
Total	**$655.56**	**$96.72**	**$74.65**	**$80.65**

Totals may not add due to rounding.

NSF has been a leader in the use of High Performance Computing (HPC) to advance discovery for almost four decades. As a result of continuous rapid changes in computing and related technologies, coupled with the exponential growth and complexity of data for the science, engineering, and education enterprise, NSF developed a new vision and strategy for Advanced Computing Infrastructure (ACI), which expands NSF's leadership role in science and engineering. This coordinated NSF-wide strategy, entitled *Cyberinfrastructure for 21st Century Science and Engineering: Advanced Computing Infrastructure,*[9] is a key component of the Cyberinfrastructure Framework for 21st Century Science, Engineering, and Education (CIF21). This strategy seeks to position and support the entire spectrum of NSF-funded communities at the cutting edge of advanced computing technologies, hardware, and software, and aims to promote a more complementary, comprehensive, and balanced portfolio of advanced computing infrastructure and programs for research and education. The strategy enables multidisciplinary computational- and data-enabled science and engineering that supports all science, engineering, and education communities. This shift is consistent with the recommendations of a 2010 review and 2012 follow-up review[10] of the Federal Networking and Information Technology R&D (NITRD) program by the President's Council of Advisors on Science and Technology (PCAST).

The overall HPC strategy and program portfolio receives guidance and input from the Advisory Committee for Cyberinfrastructure (ACCI) and its task forces as well as from the NSF cross-directorate CIF21 Council, which includes assistant directors (ADs) and office directors (ODs) from the various research directorates and offices, and the Cyberinfrastructure Coordination and Leadership Group.

PETASCALE COMPUTING – BLUE WATERS (formerly, HPC Track 1)

Description

The National Center for Supercomputing Applications (NCSA) at the University of Illinois at Urbana-Champaign (UIUC) is now providing computational resources for researchers to tackle much larger and more complex research challenges than previously possible. This was accomplished by acquiring, deploying, and operating a petascale leadership-class, high-performance system known as Blue Waters. Blue Waters is one of the most powerful supercomputers in the world, and is the fastest supercomputer on a university campus. It is important to note that this investment complements the DOE Office of Science's program on computing hardware, which provides sustained petascale performance. In contrast, Blue Waters provides peak petascale performance.

[9] www.nsf.gov/pubs/2012/nsf12051/nsf12051.pdf

[10] *Designing a Digital Future: Federally Funded Research and Development Networking and Information Technology,* President's Council of Advisors on Science and Technology, January 2013.

Blue Waters also complements the broad set of resources provided through the Innovative HPC program and eXtreme Digital (XD) environment. While Innovative HPC supports a portfolio of technically diverse systems capable of supporting hundreds to thousands of researchers over the course of a year, Blue Waters provides resources to focus on a small set of the largest and most computational-intense scientific advances demanding petascale capabilities. (For more information on Innovative HPC see below.) XD differs as well from Blue Waters in that XD delivers a broader set of capabilities to a much larger community. (For more information on XD, see the discussion on TeraGrid Phase III that is included in this appendix.)

The Blue Waters system was operational in December 2012, and the archival storage availability came online in March 2013. It is operated by NCSA and includes the Great Lakes Consortium for Petascale Computing (GLCPC) as a partner.

The Blue Waters project also includes education and outreach programs that target pre-college, undergraduate, graduate, and post-graduate students. A Virtual School of Computational Science and Engineering was established as part of the project. It created courses and certificate programs focusing on petascale computing and petascale-enabled science and engineering. The Blue Waters project has also sponsored workshops, conferences, summer schools, and seminars.

The Blue Waters project includes an annual series of workshops targeted at the developers of simulation packages and aspiring application developers. The project also includes two industrial partnership activities. The Industry Partners in Petascale Engagement (IPIPE) program provides industrial partners with a first look at the technological and scientific developments that flow from the petascale program. The Independent Software Vendor Application Scalability Forum promotes collaborations among consortium members, independent software vendors, and the industrial end-user community.

The broader impacts of this award include provisioning unique infrastructure for research and education; extensive efforts accelerating education and training in the use of high-performance computation in science; training in petascale computing techniques; promoting an exchange of information between academia and industry about the applications of petascale computing; and broadening participation in computational science through NCSA's Girls Engaged in Mathematics and Science (GEMS) program. The GEMS program is designed to encourage middle-school girls to consider mathematics- and science-oriented careers.

Current Status

In late September 2011, Cray was selected as the vendor for the Blue Waters project. Following system testing and acceptance in December 2012, and acceptance of the NCSA archival system in March 2013, the Blue Waters project entered a five-year operations phase. Support for the first six months of operations was provided in the acquisition and deployment award. Support for the remaining operational phase, from FY 2014 through mid-FY 2018, was awarded to UIUC in FY 2013.

The Blue Waters education and outreach projects are ongoing, with components on undergraduate education, graduate education, training workshops, and outreach. Annual “Petascale Workshops” provide scientists and engineers with the knowledge and expertise to develop applications for Blue Waters and other petascale computers. In addition, annual extreme scale workshops are held jointly with the Extreme Science and Engineering Discovery Environment (XSEDE) project. The Blue Waters team also hosts summer workshops and has created and offered courses through the Virtual School of Computational Science and Engineering mentioned above. Partnering with the Shodor Foundation, a nonprofit national resource for computational science education, the Blue Waters project has offered undergraduate course materials and internships. In 2014, Blue Waters Graduate Fellowships were announced for ten students from nine institutions in eight different states across the U.S.

Science and engineering research and education activities enabled by Blue Waters

Blue Waters is enabling investigators across the country to conduct innovative research demanding petascale capabilities. In particular, allocations of time on Blue Waters began in 2013 for approximately 30 teams, with a second round of awards to 14 teams made in 2014. These research teams were awarded time on Blue Waters through the Petascale Computing Resource Allocations (PRAC) process. Approximately 150 requests for usage were submitted across a wide spectrum of research areas. The research topics include: complex biological behavior in fluctuating environments; the electronic properties of strongly correlated systems; the properties of hydrogen and hydrogen-helium mixtures in astrophysically relevant conditions; the electronic and magnetic structures of transition metal compounds; the molecular dynamics responsible for the properties of liquid water; and the propagation of seismic energy through a detailed structural model of Southern California together with the predicting of ground motion and the modeling of the response of buildings and other structures. Other allocations address testing hypotheses about the role of cloud processes and ocean mesoscale eddy mixing in the dynamics of climate and improving climate models; the formation of the first galaxies; turbulent stellar hydrodynamics; binary black hole and neutron star systems as sources of gamma ray bursts; and other intense radiation phenomena, contagion, and particle physics.

Over 50 scientific papers were published each year in 2013 and 2014 based on research conducted using Blue Waters allocations. A new PRAC call was issued in November 2014, and it is anticipated that 15-20 additional awards will be made by the end of FY 2015. Furthermore, the project has issued calls for educational allocations directly involving students; including the Blue Waters undergraduate student internship program (21 students in 2014) and the Blue Waters Graduate Fellowship program (10 awards in 2014). After one year in service, Blue Waters has supported over 120 science projects (research, education, industry outreach, national, GLPCC and University) and 600 leading scientists.

Management and Oversight

NSF Structure: The project is overseen by CISE/ACI program staff and a grants officer from the Division of Grants and Agreements (DGA). These NSF staff members receive strategic advice from the CIF21 Council. Advice from the Office of General Counsel (OGC) is sought, as necessary.

External Structure: During the development and acquisition phase of this project, UIUC oversaw work by a number of sub-awardees, conducted software development, and assisted competitively selected research groups to prepare to use the Blue Waters system. The primary sub-awardee, Cray, is responsible for maintenance of the hardware, system software, and main program development tools. Other sub-awardees worked on extreme-scale parallel algorithm and method development, the engagement of applications groups, scalable performance tools, undergraduate training, and broadening the participation of underrepresented groups in high-performance computing. During the operational phase, the project team is advised by the Science and Engineering Team Advisory Committee (SETAC) whose make-up and roles were reviewed and approved by the external panel in July 2013. This Committee is composed of representatives from research teams with Blue Waters allocations, industry scientists pursuing petascale applications, and GLCPC.

Risks: The NSB will receive updates on any major change in risk assessment, which is reviewed annually by an external panel. Risks identified during the operational phase of the project include system security, power costs, and performance/reliability/usability due to large system scale.

Reviews: The project was initially selected through a competitive merit review process in 2007 and a subsequent renewal project that was reviewed and approved in 2013. An external panel of experts, selected by NSF, periodically reviews the progress of the project including project management, risk management, hardware and software performance, usability and reliability, and the provision of advanced user support to research groups receiving resource allocations on the Blue Waters system. One of the

important roles of this external review panel is to analyze the awardee's assessments of scientific merit and broader impact based on the use of the system for research and education. To date, these external reviews have been conducted in February 2008, April 2008, October 2008, April 2009, July 2009, December 2009, April 2010, September 2010, December 2010, February 2011, May 2011, September 2011, March 2012, August 2012, December 2012, July 2013, and December 2014.

INNOVATIVE HPC PROGRAM (formerly, HPC Track 2)

Description

Innovative HPC systems provide petascale peak performance. The key difference from the DOE Office of Science support for computing hardware is that each system is capable of supporting hundreds to thousands of researchers (over the course of a year) conducting leading-edge science and engineering. The portfolio of systems supported by the Innovative HPC program is intended to be technically diverse, reflecting changing and growing use of computation in both the research and education process. NSF's support complements and extends campus and regional research cyberinfrastructures. All Innovative HPC awards are made in the context of the XD program (described below).

There is a direct relationship between the Innovative HPC and XD programs. Several systems are currently serving as allocable resources within XD. Innovative HPC awards are generally made as two parts: an acquisition component with associated funding, and an operations and maintenance component with associated funding. Some Innovative HPC awards do not separate these components because of the experimental nature of the systems. When an award is made, funding is provided to the institution, which issues sub-awards to vendors for acquisitions as necessary. Once the system has passed the acceptance process, vendors receive final payment for the system. After the system has been fully tested, it becomes an XD resource and the institution becomes an XD resource provider. At this point the award funding may be used for operations and maintenance of the system.

Beginning with the FY 2011 solicitation, *High Performance System Acquisition: Enhancing the Petascale Computing Environment for Science and Engineering*, a more sustained approach to the largest HPC services was initiated. This solicitation was based on feedback from the scientific and engineering community, providing a longer time horizon for funding HPC providers in recognition of the value and time required for building and retaining staff skilled in interdisciplinary computational science. Thus, an eight- to ten-year award horizon is envisioned for a core HPC provider. This timeline begins with an acquisition award, which allows for the possibility of a renewal acquisition award four years after the original award. In addition to the acquisition awards, accompanying operations and maintenance (O&M) awards are planned.

Current Status

Machines that have been operational in the Innovative HPC program include Stampede, Blacklight, FutureGrid, Gordon, Keeneland, Kraken, Lonestar, Longhorn, and Trestles. Blacklight, FutureGrid, Kraken and Longhorn are no longer part of the current NSF HPC portfolio, although Blacklight is still supported by the Data cluster in CISE/ACI. NSF support for Gordon, Keeneland, and Trestles is scheduled to end in FY 2016.

Two new resources are now being deployed, resulting from awards made following a FY 2013 solicitation. Compared to earlier solicitations, the FY 2013 solicitation was designed to broaden the spectrum of the program by exploring new and creative approaches to delivering innovative computational resources to an increasingly diverse community and portfolio of scientific research and education projects. The goal is to include new communities with needs that are different than the more

traditional HPC users, but which would benefit from advanced computational capabilities at the national level.

The resources were funded jointly by CISE/ACI's HPC and Data programs. The first award, Wrangler, is scheduled to come online in FY 2015 at the University of Texas at Austin, and is supported by the CISE/ACI Data cluster. Upon its deployment, Wrangler will be the most powerful data analysis system allocated in XD, with 10 petabytes (PB) of replicated, secure, high performance data storage. It will consist of 3,000 embedded processing cores for data analysis; 120 Intel Haswell-based servers for data access and embedded analytics; and a large-scale flash storage tier for analytics, with bandwidth of one terabyte per second (TB/s) and 275 million Input/Output Operations Per Second (IOPS). The system will provide flexible support for a wide range of software stacks, including Hadoop and relational data, as well as integrate with Globus Online services for rapid and reliable data transfer and sharing. Support for ongoing Wrangler operations and maintenance, starting in FY 2015 and continuing through FY 2019, is provided to the University of Texas at Austin at approximately 20 percent of initial acquisition cost per annum level, consistent with the identified level provided in the FY 2013 solicitation.

The second award, Comet, also scheduled to come online in FY 2015 at the University of California at San Diego, is supported by the CISE/ACI's HPC program. It is designed to be part of an emerging cyberinfrastructure for the "long tail of science," which encompasses the idea that a large number of modestly sized computationally-based research projects still represent a tremendous amount of research and scientific impact. Notably, as a resource that is responsive to the "long tail of science," Comet is particularly well-suited for science gateway use. Its heterogeneous configuration will support not only complex simulations, but also advanced analytics and visualization of output.

A new solicitation was issued in FY 2014 (*High Performance Computing System Acquisition: Continuing the Building of a More Inclusive Computing Environment for Science and Engineering*) to continue the intent of the FY 2013 solicitation and add complementary computational resources to the NSF portfolio. This solicitation resulted in two awards: the "Bridges" system to be deployed at the Pittsburgh Supercomputing Center and "Jetstream" at Indiana University. Both systems are scheduled to be deployed in FY 2016.

Bridges will provide an innovative and groundbreaking HPC and data-analytic system that will integrate advanced memory technologies to empower new communities, bring desktop convenience to high performance computing, connect to campuses, and intuitively integrate data-intensive workflows to increase the scientific output of a large community of scientific and engineering researchers who have not traditionally used HPC resources by lowering the barrier of entry to HPC. Bridges will extend HPC's impact to minority-serving institutions and EPSCoR states, raising the level of computational awareness at four-year colleges, and promote computational thinking in high-schools.

Jetstream will be a new type of data analysis and computational resource for the open science and engineering research community that will be used interactively to conduct research anytime, anywhere. It complements the current NSF-funded computational resources portfolio by bringing online a cloud-based system incorporating the best elements of commercial cloud computing resources with some of the best software in existence for solving important scientific problems. Jetstream enables new modes of sharing computations and data, allowing for increased scientific reproducibility and enabling many US researchers and engineers to make new discoveries that are important to understanding the world around us, improving the quality of life of American citizens, and promoting America's competitive standing.

For both Bridges and Jetstream, support for ongoing operations and maintenance, starting in FY 2015 and continuing through FY 2019, is provided at approximately 20 percent of initial acquisition costs per annum, consistent with the identified level provided in the FY 2014 solicitation.

These additions replace several of the resources mentioned above that will no longer be supported, primarily Trestles and Gordon. However, they also represent additional capabilities that are intended to appeal to the larger and increasingly diverse demand for national-scale resources.

The Stampede project at the University of Texas at Austin delivered a new system for allocation of NSF XD cyberinfrastructure services in January 2013, and is scheduled to operate until January 2017. The resource and accompanying services target science and engineering researchers using both advanced computational methods and emerging data-intensive approaches. The system has boosted XD resources to nearly twice their previous capacity, and has provided researchers with early access to Intel Many Integrated Core (MIC) processors, which were accepted in August 2013.

Science and engineering research and education activities enabled by Innovative HPC

- The complete spectrum of scientific research can leverage Innovative HPC resources. This includes climate and weather modeling, economics, cosmology and astrophysics, geosciences, physics, chemistry, biology and medicine, earthquake engineering, and mechanical engineering.
- Innovative HPC is enabling world-leading transformative advances in science and engineering research, in the integration of research and education, and in broadening participation in science and engineering by underrepresented groups. These advances are enabled by providing researchers and educators with usable access to computational resources beyond those typically available on most campuses, together with the interfaces, consulting support, and training necessary to facilitate their use.
- Through the unifying XD framework and services, Innovative HPC enables researchers to manipulate extremely large amounts of digital information from simulation, sensors, and experiments, and add needed capabilities in remote visualization, an increasingly important analysis tool for modern science and engineering.
- Outreach and training critical to reducing the barriers to the use of HPC systems by the research and education community will be provided by engaging research universities and foundations. Innovative HPC incorporates new computational technologies and new approaches to software and data management, together with the expertise to enable researchers and students to complement theory and experiment with an equal emphasis in computation.

Management and Oversight

NSF Structure: CISE/ACI's program directors provide direct oversight during both the acquisition and operations phase. Formal reporting consists of quarterly and annual reports, which are reviewed by the program directors. The program directors also hold bi-weekly teleconferences with the awardees.

External Structure: Each Innovative HPC award is managed under a cooperative agreement. Each awardee is responsible for the satisfactory completion of milestones in order for the spending authorization to be raised. Progress is evaluated by annual reviews and the NSF program directors.

Each project has a detailed management plan in place. Each cooperative agreement includes the management structure, milestones, spending authorization levels, and review schedule.

Risks: Any activity of this nature, and at this scale, comes with a certain element of risk. The review process, conducted prior to award, analyzes the risks as presented in the proposal and identifies any additional risk that should be considered. The awards are experimental in nature; therefore, they encompass high-risk, high-reward scenarios. The award process requires that risks be identified and analyzed, and that a mitigation plan be created and followed. One of the activities of the periodic NSF external reviews, conducted by an external panel of experts, is to revisit and assess the risk situation and

make recommendations as deemed necessary. Risks that are no longer applicable are retired. New risks may be added, or degree of risk promoted or demoted as necessary, all of which is documented in a risk register. Typically, project risks are substantially reduced subsequent to deployment. Thus, pacing of acquisitions and deployments allows balance in overall portfolio risk for Innovative HPC.

Reviews: Semi-annual reviews are typically performed during the acquisition phase. Annual reviews, conducted by an external panel of expert reviewers, are performed during the operational phase of each project. The reviews are managed by NSF program directors. The reviewers' backgrounds include scientific research, project management, large-scale systems acquisitions and operations, and a familiarity with projects funded by NSF, as well as other federal agencies. To the extent possible, continuity through this series of reviews is provided by using the same set of reviewers.

EXTREME DIGITAL (XD) (formerly, TERAGRID PHASE III)

Description

Extreme Digital (XD), successor to the TeraGrid program, creates and maintains an advanced, nationally distributed, open cyberinfrastructure comprised of shared user and management services, supercomputing, storage, analysis, visualization systems, data services, and science gateways connected by high-bandwidth networks, integrated by coordinated policies and operations, and supported by computing and technology experts.

XD enables and supports leading-edge scientific discovery and promotes science and technology education. The program encourages innovation in the design and implementation of an effective, efficient, increasingly virtualized approach to the provision of high-end digital services, known as extreme digital services, while ensuring that the infrastructure continues to deliver high-quality access for the many researchers and educators that use it in their work.

XD shared services consist of several interrelated parts: Technology Audit Service (TAS); Technology Insertion Service (TIS); Coordination and Management Service (CMS); Extended Collaborative Support Service (ECSS; formerly Advanced User Support Service); and Training, Education and Outreach Service (TEOS). The last three elements constitute the XSEDE project; the other elements are implemented via separate awards. These elements are designed and implemented in a way that is consistent with sound system engineering principles, clearly tied to the user requirements of the science and engineering research community using a flexible methodology that permits the architecture to evolve in response to changing user needs and presents the individual user with a common user environment regardless of where the resources or user is located

Current Status

Three awards are currently active within the XD program. The two smaller awards, TAS and TIS, were made in FY 2010 to the University at Buffalo, The State University of New York, and to UIUC, respectively. The largest award, comprising CMS, ECSS and TEOS, and known as the XSEDE project, was made to UIUC in July 2011 for advanced user support, education and outreach, and management services of XD. The four additional major partners in XSEDE are the University of Texas at Austin (Texas Advanced Computer Center), the University of Pittsburgh (Pittsburgh Supercomputer Center), the University of Tennessee at Knoxville (National Center for Computational Science), and the University of California at San Diego (San Diego Supercomputer Center). XSEDE has had three annual reviews at NSF in June 2012, June 2013, and September 2014.

Science and engineering research and education activities enabled by XD

- XD services enable transformative advances in science and engineering research, in the integration of research and education, and in broadening participation in science and engineering to under-represented groups. This is accomplished by providing researchers and educators with coherent and highly usable access to extreme-scale digital resources beyond those typically available on most campuses, together with the interfaces, consulting, advanced user support, and training necessary to facilitate their use.
- XD provides high-performance computing services; enables researchers to manipulate extremely large amounts of digital information from simulations, sensors, and experiments; and adds needed capabilities in remote visualization, an increasingly important analysis tool for modern science and engineering.
- XD's XSEDE project is developing tools and services that not only link users to national facilities, but also enable scientific collaborations of geographically distributed teams. In doing so, it facilitates access to digital resources and experimental testbeds within and across university campuses, as well as government laboratories.
- The XSEDE project includes outreach and training critical to reducing the barriers to the use of advanced digital systems by the research and education communities. The project incorporates new ideas and technologies to enable researchers and students to move transparently between local and national resources, substantially lowering the barriers to effective use of cyberinfrastructure and promoting enhanced productivity.

Management and Oversight

NSF Structure: CISE/ACI program directors oversee the TAS, TIS, and XSEDE projects. XSEDE has an external advisory board, a user board, and a service provider forum to ensure that all stakeholders can provide project input. CISE/ACI oversight of the XSEDE project includes participation in weekly teleconferences with senior XSEDE personnel and in the quarterly project-wide staff meetings. Formal reporting consists of quarterly and annual reports, which are reviewed by the program directors.

External Structure: Each XD award is managed under a cooperative agreement. Each awardee is responsible for the satisfactory completion of milestones prior to processing of grant increments. Each project has a detailed management plan in place. Each cooperative agreement includes the management structure, milestones, spending levels over time, and review schedule.

Risk: While XD is operational in nature, the virtual organizations of the XSEDE project and the services of all XD projects are innovative and thus bear inherent risks. The projects maintain risk registers that are reviewed periodically by external panels and by the cognizant program directors. Identified risks and planned actions are reported to, and reviewed with, the program directors.

Reviews: Annual reviews (for XSEDE) and mid-project reviews (for TIS and TAS) are conducted by an external panel of expert reviewers. The reviews are managed by the program directors. The reviewers' backgrounds include scientific research, project management, operations of HPC centers, and familiarity with projects funded by NSF, as well as other federal agencies. To strike a balance between continuity and broad community engagement, approximately half of the annual review panel members have served in this role previously while the other half are new members.

DIRECTORATE FOR ENGINEERING (ENG) $949,220,000
+$56,910,000 / 6.4%

ENG Funding

(Dollars in Millions)

	FY 2014[1] Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Chemical, Bioengineering, Environmental, and Transport Systems (CBET)	$167.76	$177.82	$192.26	$14.44	8.1%
Civil, Mechanical, and Manufacturing Innovation (CMMI)	195.23	209.52	222.73	13.21	6.3%
Electrical, Communications, and Cyber Systems (ECCS)	100.37	110.43	119.24	8.81	8.0%
Engineering Education and Centers (EEC)	119.50	117.49	110.39	-7.10	-6.0%
Industrial Innovation and Partnerships (IIP)	205.99	226.98	248.11	21.13	9.3%
Emerging Frontiers and Multidisciplinary Activities (EFMA)	44.27	50.07	56.49	6.42	12.8%
Total, ENG	**$833.12**	**$892.31**	**$949.22**	**$56.91**	**6.4%**

Totals may not add due to rounding.

[1] The Office of Emerging Frontiers and Multidisciplinary Activities (EFMA) is the reorganized form of Emerging Frontiers in Research and Innovation (EFRI), beginning in FY 2015. FY 2014 Actual obligations for all divisions have been restated for comparability.

About ENG

Fundamental research supported by the Directorate for Engineering (ENG), combined with the creativity of well-educated engineers and the resources of state-of-the-art facilities, has resulted in many important discoveries and inventions. These advances have fueled exciting technological innovations, including, for example, nanotechnology-enabled consumer, industrial, and health care products and manufacturing; novel laser-based tools for brain research and neurological diseases; wireless devices and communications and computing systems; and internet-enabled smart advanced manufacturing systems and supply chains, that in turn have strengthened our Nation's innovation ecosystem, stimulated economic growth, enhanced national security, and improved the quality of life for all Americans.

ENG aims to bring about new technological breakthroughs to address national priorities and grand challenges by (1) investing in key Administration and NSF-wide priorities, and (2) supporting frontier engineering research, education, and innovation through core programs.

ENG investments will support Administration priorities such as the Brain Research through Advancing Innovative Neurotechnologies (BRAIN) Initiative, the Advanced Manufacturing Partnership (AMP), clean energy technology, the National Nanotechnology Initiative (NNI), and the National Robotics Initiative (NRI).

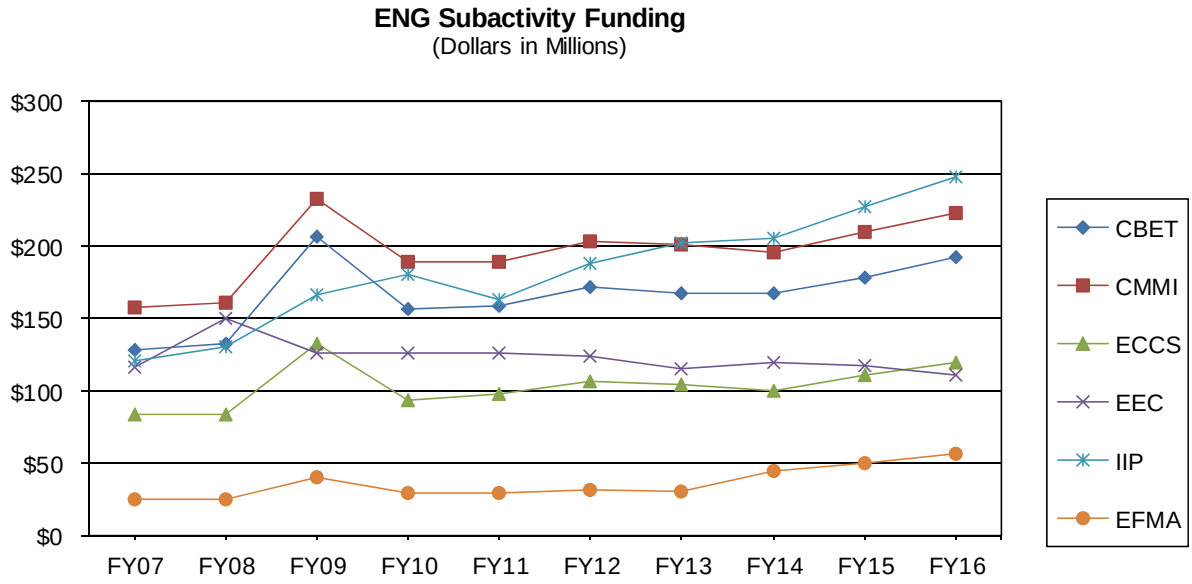
ENG will lead or contribute directly to NSF-wide strategic investments in programs such as Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS), Risk and Resilience (via the Critical Resilient Interdependent Infrastructure Systems and Processes (CRISP) program), Cyber-enabled Materials, Manufacturing, and Smart Systems (CEMMSS), the NSF Innovation Corps (I-Corps™),

Understanding the Brain (UtB), Optics and Photonics, Improving Undergraduate STEM Education (IUSE) via the Professional Formation of Engineers: Revolutionizing Engineering Departments (PFE:RED) program, and Inclusion across the Nation of Communities of Learners that have been Underrepresented for Diversity in Engineering and Science (NSF INCLUDES).

The directorate will continue to invest throughout its core programs in emerging and frontier basic research areas, including, for example, systems science and engineering, next generation electronic and computing devices, circuits, and systems, and the engineering of biology. Through support of small businesses and academic partnerships with industry, ENG will help bring high-impact technological innovations into the market and support the national innovation ecosystem.

ENG will continue to develop the next-generation engineering workforce through offering hands-on research opportunities to students and through supporting engineering education research. Engineering education is undergoing major changes with significant increases in student enrollments across the nation. At the same time, it is essential to better prepare engineering students to be the future leaders and innovators in engineering research and in industry, and to work in a constantly changing global economy. Additionally, the engineering education ecosystem continues to face major challenges in attracting women and underrepresented minorities. ENG will continue to identify and support systemic innovations to meet these critical and compelling challenges. Programs such as IUSE (via PFE:RED) and NSF INCLUDES are designed to meet these challenges.

ENG provides about 33 percent of the federal funding for basic research at academic institutions in the engineering sciences.



The Office of Emerging Frontiers and Multidisciplinary Activities (EFMA) is the reorganized form of Emerging Frontiers in Research and Innovation (EFRI), beginning in FY 2015. FY 2014 Actual obligations for all divisions have been restated for comparability.

FY 2009 funding reflects both the FY 2009 omnibus appropriation and funding provided through the American Recovery and Reinvestment Act of 2009 (P.L. 111-5).

FY 2016 Summary by Division

- CBET's FY 2016 Request will support research and education in the areas of the food, energy, and water nexus by contributing to the NSF-wide INFEWS investment. CBET will continue to support transformative work in collaboration with life/physical sciences through UtB and the Research at the Interface of the Biological, Mathematical and Physical Sciences (BioMaPS) programs. CBET will bolster CEMMSS support through investments in advanced biomanufacturing that focuses on studying theories and technologies of design, engineering, and manufacturing bio-related (natural or synthetic) products; and robotics research to assist those with physical disabilities or cognitive impairment. CBET will enhance support of research in Synthetic Biology focusing on metabolic engineering and the engineering aspects of Synthetic Biology. CBET will continue to invest in novel ideas for clean energy technologies. CBET will also enhance support for early-career researchers and continue to support a Science and Technology Center (STC) from the Class of 2010.

- CMMI's FY 2016 Request will enable contributions to the CEMMSS investment through research and education in advanced manufacturing; interdisciplinary research in advanced materials and manufacturing processes; materials design, robotics, and cyber-manufacturing to enable research on the networked integration of manufacturing machines, equipment, and systems into an increasingly accessible manufacturing service infrastructure. CMMI's request will contribute to the NSF-wide priority Risk and Resilience through the CRISP program to deepen fundamental knowledge and stimulate innovations to improve resilience, interoperations, performance, and readiness in interdependent critical infrastructure systems. Cyberinfrastructure Framework for 21st Century Science, Engineering, and Education (CIF21) support will focus on research and education on computational-based approaches for engineering design, analysis, and predictive modeling, particularly under high degrees of uncertainty. CMMI's contribution to Science, Engineering, and Education for Sustainability (SEES) will include research for resilient and sustainable buildings and infrastructure, disaster-resilient systems, energy systems manufacturing, and energy-efficient materials and processes.

- ECCS's FY 2016 Request will invest in the Enhanced Access to the Radio Spectrum (EARS) activity to support research on more efficient radio spectrum use and greatly improved low-power energy-conserving device technologies. The division will also provide support for CEMMSS-related work in robotics, smart health research, and cyber-physical systems in the area of integration of intelligent decision-making algorithms and hardware into physical systems. ECCS will support the CIF21 program through research and education in advanced devices and systems directed towards computing, data storage, networking, and data management. ECCS's Request will also enable research in Urban Science to increase our understanding of how to intelligently and effectively design, adapt, and manage cities to maximize their positive potential while minimizing negative unintended consequences. ECCS will increase its support to critical areas of national importance such as UtB, advanced electronic materials, and low-power computing. ECCS will also enhance support for early-career researchers and support an STC.

- EEC's FY 2016 Request will provide funding for a combination of Engineering Research Centers (ERC) and Nanosystems Engineering Research Centers (NERCs), including planned growth supplements for three new centers awarded as part of the Class of 2015. In FY 2016, EEC will support PFE:RED to enable engineering departments to achieve significant sustainable changes necessary to overcome long-standing issues in their undergraduate programs and educate inclusive communities of engineering students prepared to solve 21st century challenges. PFE:RED will be under the framework of the NSF-wide IUSE activity, which integrates the agency's investments in undergraduate education. Engineering Education and Nanotechnology Undergraduate Education

(NUE) undergraduate programs were consolidated into IUSE in FY 2014. EEC will continue to support research and development leading to and propagating interventions that improve both the quality and quantity of STEM graduates. For more information regarding IUSE and NSF's undergraduate framework, see the IUSE narrative in the NSF-Wide Investments chapter. Support for the Research Experiences for Undergraduates (REU) program will be maintained, with a particular focus on providing early opportunities to conduct research.

- IIP's FY 2016 Request reflects its commitment to enhancing the Nation's innovation ecosystem. Through programs for Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR), IIP will continue to support technological breakthroughs that benefit society. Through I-Corps™, Partnerships for Innovation (PFI), Industry/University Cooperative Research Centers Program (I/UCRC), and other activities, the division will enable academic researchers to translate fundamental research discoveries into market realities, and encourage academia and industry to collaborate and prepare students to be innovators and entrepreneurs.

- EFMA's FY 2016 Request will provide support for 16 Emerging Frontiers in Research and Innovation (EFRI) interdisciplinary teams to pursue cutting-edge research with the potential for transformative impacts on national needs and grand challenges.

Major Investments

ENG Major Investments
(Dollars in Millions)

Area of Investment	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
BioMaPS	$4.31	$3.00	$3.00	-	-
CAREER	59.60	50.91	51.58	0.67	1.3%
CEMMSS	97.79	96.81	107.52	10.71	11.1%
Advanced Manufacturing	*80.91*	*79.96*	*80.15*	*0.19*	*0.2%*
Clean Energy	128.00	137.56	140.87	3.31	2.4%
CIF21	12.00	10.00	10.00	-	-
I-Corps™	8.17	11.00	13.00	2.00	18.2%
NSF INCLUDES	-	-	1.40	1.40	N/A
INFEWS	-	-	13.00	13.00	N/A
IUSE	5.45	6.00	6.00	-	-
NRT[1]	4.72	2.85	2.59	-0.26	-9.1%
Optics and Photonics	110.00	112.00	114.00	2.00	1.8%
Risk and Resilience	11.00	12.00	17.00	5.00	41.7%
SEES	13.20	12.00	3.00	-9.00	-75.0%
SaTC	3.75	3.25	3.25	-	-
Understanding the Brain	8.63	10.99	16.75	5.76	52.4%
Urban Science	-	-	2.00	2.00	N/A

Major investments may have funding overlap and thus should not be summed.

[1] Outyear commitments for Integrative Graduate Education and Research Traineeship (IGERT) are included in the NRT line and are $4.72 million in FY 2014, $1.13 million in FY 2015, and $1.81 million in FY 2016.

- BioMaPS ($3.0 million, equal to the FY 2015 Estimate): ENG support seeks to contribute to the understanding of biology using engineering tools to exploit unique aspects of biological systems in applications that are useful in industrial, environmental, and health care arenas. Funding for this activity is in the CBET and CMMI divisions.

- Faculty Early Career Development (CAREER) (+$670,000, to a total of $51.58 million): Supports young investigators who exemplify the role of teacher–scholar through outstanding research, excellent education, and the integration of education and research within the context of the mission of their organizations.

- CEMMSS (+$10.71 million, to a total of $107.52 million): Support will build upon existing frontier engineering research and advance connections among breakthrough materials, advanced manufacturing, robotics, and cyber-physical systems leading to enhanced disciplinary and interdisciplinary research.

- Advanced Manufacturing (+$190,000, to a total of $80.15 million): Provides support for research in nanosystems design and scalable nano-manufacturing; additional emphasis on the "Factory of the Future": Cyber-enabled, adaptive, agile distributed manufacturing; and increased focus on advanced biomanufacturing. ENG will maintain close connections with efforts by other agencies to raise U.S. manufacturing capacity by ensuring an appropriate link with the NSF investments in fundamental research and education in manufacturing.

- Clean Energy Technology (+$3.31 million, to a total of $140.87 million): ENG support of clean energy technology-related activities will enhance research and innovations in smart grid technologies, solar energy technologies, biofuels and bioenergy, wind energy generation, and renewable energy storage. The ENG clean energy technology investment will be strategically coordinated across all divisions.

- CIF21 ($10.0 million, equal to the FY 2015 Estimate): ENG support will focus on computational and data-enabled science and engineering research, infrastructure, and community building, and access and connections to cyberinfrastructure facilities. Funding is in CBET, CMMI, and ECCS.

- I-Corps™ (+$2.0 million, to a total of $13.0 million): ENG will continue to lead the NSF-wide I-Corps™ program. In FY 2016, ENG will support I-Corps™ Teams, Sites, and Nodes to further build, utilize, and sustain a national innovation ecosystem that continues to augment the development of technologies, products, and processes that benefit the Nation. Funding is through IIP.

- NSF INCLUDES (+$1.40 million, to a total of $1.40 million): ENG will align its investments in this NSF-wide effort to increase participation of underrepresented groups in STEM fields.

- INFEWS (+$13.0 million, to a total of $13.0 million): FY 2016 funding represents the initial investment in this NSF-wide activity. ENG will support fundamental engineering research required to understand, model, and design food-energy-water systems. INFEWS will leverage existing ENG programs in energy, water, and biotechnology, which support projects such as ones to reduce water consumption in power plants.

- IUSE ($6.0 million, equal to the FY 2015 Estimate): ENG will participate in the NSF-wide IUSE activity, which integrates the agency's investments in undergraduate education. In FY 2016, ENG will continue to support PFE:RED under the IUSE framework to enable research and development

leading to and propagating interventions that improve both the quality and quantity of engineering graduates.

- NSF Research Traineeship (NRT) (-$260,000, to a total of $2.59 million): ENG will continue to participate in the NRT program, which is the successor to the Integrative Graduate Education and Research Traineeship (IGERT). The FY 2016 decrease reflects a continuing reduction in the remaining commitments to the IGERT program as it is sunsetting.

- Optics and Photonics (+$2.0 million, to a total of $114.0 million): ENG supports research and engineering efforts leading to significant advances in novel optical sources and photodetectors, optical communication devices, photonic integrated circuits, single-photon quantum devices, and nanophotonics. ENG will increase support of multidisciplinary research in the optics and photonics area with emphasis on nanoscale devices and systems. Applications in high-speed optical communications for environmental and biomedical research will be encouraged.

- Risk and Resilience (+$5.0 million, to a total of $17.0 million): ENG will co-lead this priority area with the Directorate for Geosciences to advance knowledge of risk assessment and predictability, and to support the creation of tools and technologies for increased resilience. In FY 2016, ENG will continue to support the CRISP program by catalyzing collaborations among researchers across the domains of engineering; computer and computational science; and social, behavioral, and economic sciences to deepen fundamental knowledge and stimulate innovations to improve resilience, interoperations, performance, and readiness of our critical infrastructure.

- SEES (-$9.0 million, to a total of $3.0 million): Investment is decreased as program activities sunset. Funds will be re-invested in INFEWS, Risk and Resilience, and other priorities within the ENG portfolio. ENG will continue to support Sustainable Chemistry research.

- Secure and Trustworthy Cyberspace (SaTC) ($3.25 million, equal to the FY 2015 Estimate): ENG support for SaTC will focus on the engineering aspects of the Networking and Information Technology Research and Development (NITRD) Strategic Plan for the Federal Cybersecurity Research and Development Program. NITRD's research thrusts cover a set of interrelated priorities for U.S. government agencies that conduct or sponsor research and development in cybersecurity.

- UtB (+$5.76 million, to a total of $16.75 million): ENG will invest in UtB and neuroscience research critical to success of the BRAIN Initiative and integral to activities associated with the multidisciplinary nature of this investment. Research will drive integration across scales and across disciplines, and accelerate the development of new experimental and analytical approaches, including computational and data-enabled modeling, and new neural engineering and technology research and development.

- Urban Science: ENG will make an initial investment of $2.0 million in the urban science activity. In partnership with the Directorates for Computer and Information Science and Engineering (CISE) and Social, Behavioral, and Economic Sciences (SBE), ENG will support research to increase our understanding of how to intelligently and effectively design, adapt, and manage cities to maximize their positive potential while minimizing negative unintended consequences.

ENG Funding for Centers Programs and Facilities

ENG Funding for Centers Programs
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, Centers Programs	**$86.78**	**$79.25**	**$67.25**	**-$12.00**	**-15.1%**
Engineering Research Centers (EEC)	70.06	64.50	56.50	-8.00	-12.4%
Nanoscale Science & Engineering Centers (multiple)	4.98	4.75	0.75	-4.00	-84.2%
Science and Technology Centers (multiple)	10.08	10.00	10.00	-	-
Science of Learning Centers (EEC)	1.66	-	-	-	N/A

Totals may not add due to rounding.

For detailed information on individual centers, please see the NSF-Wide Investments chapter.

- Support for the ERC program decreases by $8.0 million, to a total of $56.50 million. Decreased support will result in a reduction in the number of centers from 19 to 15, as the program is between competition years in FY 2016. The next class of ERCs will be funded in FY 2017. Funding and numbers of centers include three Nanosystems ERCs that were first supported in FY 2012.
- NSEC support will be reduced by $4.0 million, to a total of $750,000, as the program continues to sunset as planned. It is anticipated core programs in ENG will increase support to nanoscale science and engineering, offsetting the reduction.
- ENG will continue to fund two STCs in FY 2016. CBET will support the Center on Emergent Behaviors of Integrated Cellular Systems, and ECCS will support the Center for Energy Efficient Electronics Science.
- ENG funding of a directorate-supported Science of Learning Center (SLC) ended as the center received its final year funding in FY 2014 as planned.

ENG Funding for Facilities
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, Facilities	**$33.85**	**$27.83**	**$28.33**	**$0.50**	**1.8%**
Cornell High Energy Synchrotron Source (CHESS)	5.04	5.00	5.00	-	-
Natural Hazards Engineering Research Infrastructure (NHERI)	-	12.00	12.50	0.50	4.2%
National Nanotechnology Coordinated Infrastructure (NNCI)	-	10.83	10.83	-	-
National Nanotechnology Infrastructure Network (NNIN)	10.67	-	-	-	N/A
Network for Earthquake Engineering and Simulation (NEES)	18.14	-	-	-	N/A

Totals may not add due to rounding.

For detailed information on individual facilities, please see the Facilities chapter.

- Support for CHESS operations and maintenance costs are maintained at $5.0 million, equal to the FY 2015 Estimate.
- Support for the Natural Hazards Engineering Research Infrastructure (+$500,000, to a total of $12.50 million) is consistent with the cooperative agreement for this earthquake engineering facility, which replaced the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES) operations in FY 2015.
- ENG continues support for nanotechnology research infrastructure through investment in the National Nanotechnology Coordinated Infrastructure (NNCI) ($10.83 million, equal to the FY 2015 Estimate). This network of user facilities replaced the National Nanotechnology Infrastructure Network (NNIN) in FY 2015.

Summary and Funding Profile

ENG supports investment in core research, innovation, and education as well as research infrastructure such as facilities.

In FY 2016, the number of research grant proposals is expected to be about 9,800. ENG expects to award approximately 1,600 research grants in FY 2016. Average annualized award size and duration are estimated to be $133,000 and three years, respectively, in FY 2016.

In FY 2016, funding for centers accounts for slightly less than nine percent of ENG's non-SBIR/STTR Request.

Funding for facilities is slightly less than four percent of ENG's non-SBIR/STTR FY 2016 Request.

ENG Funding Profile

	FY 2014 Actual Estimate	FY 2015 Estimate	FY 2016 Estimate
Statistics for Competitive Awards:			
Number of Proposals	11,885	12,240	12,600
Number of New Awards	2,152	2,260	2,330
Funding Rate	18%	18%	18%
Statistics for Research Grants:			
Number of Research Grant Proposals	9,259	9,550	9,840
Number of Research Grants	1,502	1,570	1,620
Funding Rate	16%	16%	16%
Median Annualized Award Size	$111,547	$112,000	$112,500
Average Annualized Award Size	$130,993	$132,000	$133,000
Average Award Duration, in years	3.0	3.0	3.0

Program Monitoring and Evaluation

External Program Evaluations and Studies:

- In FY 2014, NSF's Evaluation and Assessment Capability office commissioned a study of the feasibility of conducting rigorous impact evaluation of I-Corps™ Teams. The study, which concluded in October 2014, was aimed at exploring methodological options for rigorous impact

evaluation of the program. NSF is currently evaluating the recommendations and determining the next steps for evaluation of the I-Corps™ Teams program.

- A pilot test of the question items and logic model developed for the EFRI program will be finalized in the second quarter of FY 2015. The study encompasses a complete data collection effort for the first two cohorts and an evaluation of the burden on principal investigators and availability of data. This pilot will inform the FY 2016 development of a permanent longitudinal outcome monitoring system for the EFRI program that will inform program management decision-making and will enable access to outcome data for rigorous evaluation.
- In FY 2014, the IIP division completed logic models and associated indicators for all programs. In FY 2015 and FY 2016, the directorate will continue the efforts by following NSF-wide approaches and frameworks to evaluate and assess fundamental and translational research.
- In FY 2016, the directorate will utilize the developing NSF Business Intelligence platform and the output data available from the Research Performance Progress Report (RPPR) and open access to create dashboards and automated reports aimed at visualizing the output of programs, clusters, divisions, and the directorate, and their relationships with other factors and variables.

Science and Technology Policy Institute (STPI) Reports:

- CMMI supported STPI for a retrospective assessment of solid freeform fabrication/additive manufacturing (SFF) that concluded in November 2013. The project researched and identified how SFF-related fundamental research sponsored by the agency originated and evolved since its initiation. Analytical input was provided regarding major research directions, the outcomes from NSF support (major discoveries, new technologies and affected industries, and development of a SFF community), factors affecting innovation, and lessons learned that can be used to help design future activities similar to NSF's Strategic Manufacturing (STRATMAN) program that, in part, helped launch and mature SFF technologies, and to inform NSF's participation in the Additive Manufacturing Innovation Institute.[1]

Workshops and Reports:

- A three-day Advanced Biomanufacturing Workshop was conducted in July 2014, in Talloires, France. The workshop was a follow up on the NSF-sponsored workshop on Advanced Biomanufacturing held July 25-26, 2013, in Arlington, Virginia. The 2014 workshop provided a comprehensive overview of Advanced Biomanufacturing, including molecular approaches and building blocks, cellular approaches, assemblies and polymers, tissue and organ approaches, and systems integration. The workshop permitted more focused discussions among a smaller group of participants, including investigators from European institutions, which was not the case in the initial workshop that included only U.S. investigators.
- A workshop on Assessment of International R&D on Biological Engineering & Manufacturing (BE&M) was convened on November 5, 2014, in Arlington, VA. This workshop reviewed the results from a study assessing international research and development activities in advanced biological engineering and manufacturing. The objectives of the study were to assess worldwide biomanufacturing capabilities, to identify technological and scientific gaps and opportunities for international collaboration, and to pinpoint areas where funding should be directed to enable advances in technologies supporting the new generation of medical therapies based on living cells, tissue engineering, and regenerative medicine approaches.[2]
- A three-day workshop on Noninvasive Imaging of Brain Function was conducted in July 2014, in Arlington, VA. The workshop focused on identifying current limitations in imaging brain function *in vivo* and on discussing emerging technologies that could expand the reach of noninvasive human functional brain imaging. Recognized national experts were invited to discuss the three main aspects

[1] www.ida.org/upload/stpi/pdfs/p5091final.pdf
[2] www.wtec.org/bem/#intro

of noninvasive imaging of brain function: imaging modalities, sensors and nanoreceptors, and algorithms and computational approaches.[3]

- A workshop on Frontiers of Additive Manufacturing Research and Education was held on July 11-12, 2013, in Gainesville, FL. The workshop provided a forum for sharing ideas and disseminating information about the frontiers of additive manufacturing research, education, and technology transfer. The workshop covered the following four themes: 1) technology and applications; 2) processes, machines, materials, and design; 3) university-industry collaboration and technology transfer; and 4) education and training.[4]

Committees of Visitors (COV):

- In September 2014, COVs reviewed ECCS and EFRI. The COVs will present their reports to the ENG Advisory Committee that will be convened in April 2015.
- In 2015, COVs will review CBET and CMMI.
- In 2016, COVs will review EEC and IIP.

The Performance chapter provides details regarding the periodic reviews of programs and portfolios of programs by external Committees of Visitors and directorate Advisory Committees. Please see this chapter for additional information.

Number of People Involved in ENG Activities

	FY 2014 Actual Estimate	FY 2015 Estimate	FY 2016 Estimate
Senior Researchers	8,356	8,700	9,100
Other Professionals	1,695	1,800	1,900
Postdoctorates	382	400	400
Graduate Students	7,327	7,700	8,100
Undergraduate Students	4,183	4,400	4,600
Total Number of People	**21,943**	**23,000**	**24,100**

[3] http://people.bu.edu/bifano/NSF_NIBF_Workshop_Report_Final.pdf
[4] http://search.ufl.edu/web/#gsc.tab=0&gsc.q=nsf%20report

DIVISION OF CHEMICAL, BIOENGINEERING, ENVIRONMENTAL, AND TRANSPORT SYSTEMS (CBET)

$192,260,000
+$14,440,000 / 8.1%

CBET Funding
(Dollars in Millions)

	FY 2014[1] Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Percent
Total, CBET	**$167.76**	**$177.82**	**$192.26**	**$14.44**	**8.1%**
Research	**162.50**	**173.03**	**187.42**	**14.39**	**8.3%**
CAREER	25.83	21.84	22.13	0.29	1.3%
Centers Funding (total)	6.64	6.57	5.33	-1.24	-18.9%
Nanoscale Science & Engineering Centers	1.60	1.57	0.33	-1.24	-79.0%
STC for Emergent Behavior	5.04	5.00	5.00	-	-
Education	**1.56**	**1.10**	**1.15**	**0.05**	**4.5%**
Infrastructure	**3.71**	**3.69**	**3.69**	**-**	**-**
National Nanotechnology Coordinated Infrastructure (NNCI)	-	3.69	3.69	-	-
National Nanotechnology Infrastructure Network (NNIN)	3.71	-	-	-	N/A

Totals may not add due to rounding.

[1] FY 2014 Actual obligations have been restated for the FY 2015 reorganization of the Office of Emerging Frontiers and Multidisciplinary Activities (EFMA) from Emerging Frontiers in Research and Innovation (EFRI) for comparability.

CBET supports research to enhance and protect U.S. national health, energy, food, water, environment, process manufacturing, and security. Through CBET, the physical, chemical, life, and social sciences are integrated in engineering research and education, resulting in advances in the rapidly evolving fields of biotechnology, bioengineering, advanced materials, environmental engineering, and sustainable energy. CBET also invests in areas that involve the transformation and/or transport of matter and energy by chemical, thermal, or mechanical means. CBET investments contribute significantly to the knowledge base and to the development of the workforce for major components of the U.S. economy, including chemicals, pharmaceuticals, medical devices, specialty chemicals, and materials for advanced manufacturing, natural gas and petroleum production, food, textiles, utilities, and microelectronics.

CBET supports the chemical, environmental, biomedical, mechanical, civil, and aerospace engineering disciplines. To serve these communities and achieve its goals, CBET is organized into four thematic clusters: Chemical and Biochemical Systems; Biomedical Engineering and Engineering Healthcare; Environmental Engineering and Sustainability; and Transport, Thermal, and Fluid Phenomena.

In general, 75 percent of the CBET portfolio is available for new research grants and 25 percent is available for continuing grants.

FY 2016 Summary
All funding decreases/increases represent change over the FY 2015 Estimate.

Research

- CAREER funding increases by $290,000 to a total of $22.13 million in FY 2016. This increase is consistent with CBET's emphasis on supporting early-career researchers.

- CBET's investment in SEES decreases by $5.0 million, to a total of $2.25 million, as involvement in this program's activities sunset. Funds will be re-invested in INFEWS, Risk and Resilience through the CRISP activity, and other priorities within the portfolio.
- An initial investment of $5.0 million is made in the NSF-wide INFEWS emphasis. CBET programs support fundamental engineering research in energy, water, and biotechnology, and in research projects focusing on sustainable water and energy use. Support will also be provided for projects to advance the understanding of the complex food-energy-water system and water-energy, food-energy, and food-water subsystems, as well as their interdependencies. In addition, support will be provided that explores potential technological innovations that incorporate sustainability, safety/security/protection, efficiency, and affordability.
- Support is increased by $3.50 million, to a total of $9.0 million, for research in the UtB investment area. This activity holds promise for revealing fundamental principles underlying brain structure and function and for enhancing understanding of the brain through the development of new technologies and theories. Support will also focus on proposals from interdisciplinary teams of researchers poised to promptly address targeted issues in innovative experimentation; neurotechnology development; modeling and simulation; and quantitative theory development. One major objective of these investments is to establish truly transdisciplinary team-based brain research that rises above the work of existing disciplines.
- Increased support of $5.0 million over the FY 2015 Estimate is requested in the area of Synthetic Biology research. Synthetic Biology – design, construction, and analysis of existing and/or novel biological parts, devices, and systems using principles from biology and engineering – has been identified as one of the most promising research directions in recent years. This encompasses very fundamental research as well as the creation of new technologies that have enormous potential to revolutionize biomanufacturing, create new materials, and develop innovative tools that will allow us to unravel the mysteries of complex biological systems.
- CBET plans to enhance support for research in advanced biomanufacturing that focuses on studying theories and technologies of design, engineering, and manufacturing bio-related (natural or synthetic) products, such as cells and cell-based therapeutic products (i.e. individualized tissues and organoids), or devices with biomaterials and/or cells as components. This program will leverage the Biomedical Engineering and Biotechnology and Biochemical Engineering programs in CBET.
- Investments for CIF21 total $2.0 million, and will contribute to develop a cyberinfrastructure of sustainable computation that allows the use of expert algorithms by multiple groups (including undergraduates and industrial practitioners) less experienced than experts to perform calculations after minimal instruction. Existing resources (envelopes, clouds, open source modules, etc.) will be used to create this environment of learning and discovery.
- The division will also provide $2.0 million in support of the national Materials Genome Initiative (MGI), through a collaborative effort with the Directorate for Mathematical and Physical Sciences (MPS) in Designing Materials to Revolutionize and Engineer our Future (DMREF) under the NSF-wide CEMMSS investment area.
- STC funding remains $5.0 million, equivalent with the FY 2015 Estimate, to continue support for the STC on Emergent Behavior of Integrated Cellular Systems, led by the Massachusetts Institute of Technology.
- CBET support for the NSEC program totals $330,000, as the program continues to sunset as planned.

Education

- CBET contributes to a number of education and diversity activities, including REU and NSF's Career Life Balance (CLB) activity. Total CBET funding for these activities in the FY 2016 Request is $1.15 million. CLB funding is maintained at the FY 2015 Estimate and funding for REU supplements increases by $50,000.

Infrastructure

- CBET continues support for infrastructure in FY 2016 through investments in the NNCI at the FY 2015 Estimate level.

DIVISION OF CIVIL, MECHANICAL, AND MANUFACTURING INNOVATION (CMMI) — $222,730,000 +$13,210,000 / 6.3%

CMMI Funding

(Dollars in Millions)

	FY 2014[1] Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, CMMI	**$195.23**	**$209.52**	**$222.73**	**$13.21**	**6.3%**
Research	**173.83**	**193.92**	**206.58**	**12.66**	**6.5%**
CAREER	19.95	16.97	17.19	0.22	1.3%
Centers Funding (total)	1.24	1.35	0.31	-1.04	-77.0%
Nanoscale Science & Engineering Centers	1.24	1.35	0.31	-1.04	-77.0%
Education	**1.35**	**1.70**	**1.75**	**0.05**	**2.9%**
Infrastructure	**20.06**	**13.90**	**14.40**	**0.50**	**3.6%**
Natural Hazards Engineering Research Infrastructure (NHERI)	-	12.00	12.50	0.50	4.2%
National Nanotechnology Coordinated Infrastructure (NNCI)	-	1.90	1.90	-	-
National Nanotechnology Infrastructure Network (NNIN)	1.92	-	-	-	N/A
Network for Earthquake Engineering and Simulation (NEES)	18.14	-	-	-	N/A

Totals may not add due to rounding.

[1] FY 2014 Actual obligations have been restated for the FY 2015 reorganization of the Office of Emerging Frontiers and Multidisciplinary Activities (EFMA) from Emerging Frontiers in Research and Innovation (EFRI) for comparability.

CMMI funds fundamental research in support of the Foundation's strategic goals directed at advances in the disciplines of civil, mechanical, industrial, systems, manufacturing, and materials engineering. In addition, the division has a focus on the reduction of risks and damage resulting from earthquakes, wind and other hazards. CMMI encourages discovery enabled by the use of cross-cutting technologies such as adaptive systems, nanotechnology, and high-performance computational modeling and simulation. The division promotes cross-disciplinary research partnerships at the intersections of traditional research disciplines to achieve transformative research results that promote innovative manufacturing technology; enable the design and analysis of complex engineering systems; enhance the sustainability and resilience of U.S. infrastructure (for example, buildings, transportation, and communication networks); help protect the Nation from extreme natural events; and apply engineering principles to improve the Nation's service and manufacturing enterprise systems, including healthcare.

In general, 81 percent of the CMMI portfolio is available for new research grants and 19 percent is available for continuing grants.

FY 2016 Summary

All funding decreases/increases represent change over the FY 2015 Estimate.

Research

- CAREER funding increases by $220,000, to a total of $17.19 million, in FY 2016. This increase is consistent with CMMI's emphasis on supporting early-career researchers.

- Fundamental core research in support of advanced manufacturing will increase by $190,000, to a total of $51.02 million, as part of the NSF-wide CEMMSS activity. Areas of continued emphasis include nanomanufacturing, materials engineering and processing, service and manufacturing enterprise systems and operations research, smart manufacturing, and design and manufacturing of complex engineered systems.
- Research to support NRI will be maintained at $5.0 million, equal to the FY 2015 Estimate, to contribute to ensuring continued U.S. leadership in the robotics field.
- The division will also maintain funding of $7.0 million, equal to the FY 2015 Estimate, in support of the national MGI through the DMREF effort under the NSF-wide CEMMSS investment area.
- Increased support of $2.0 million, to a total of $7.0 million, is made in the agency's Risk and Resilience focus through the CRISP program. Support will be provided to promote interdisciplinary research needed to produce the new knowledge required for transforming our infrastructure, as well as for CRISP interdisciplinary research (engineering, computer science, social/behavioral/economic sciences) focused on the understanding, design, and management of critical interdependent infrastructures systems and processes. These systems and processes are required to provide essential goods and services despite hazards stemming from causes natural, technological, or malicious.
- Support for CIF21 remains $5.50 million in FY 2016. CMMI will contribute to this NSF-wide investment by supporting research on computationally-based approaches for engineering design, analysis, and predictive modeling, particularly under high degrees of uncertainty. Efforts will support research in the areas of data-enabled science and engineering, with emphasis on complex systems design and analysis, and methods to utilize disparate and distributed data sets for CMMI-relevant research. Linkages between these CEMMSS-related research programs and elements of the CIF21 activity will be strengthened, as researchers make greater use of modeling and simulation, and data-enabled capabilities made possible by CIF21 investments.
- CMMI support for the NSEC program totals $310,000, a reduction of $1.04 million, as the program continues to sunset as planned.

Education

- CMMI contributes to a number of education and diversity activities, including REU and CLB. Total CMMI funding for these activities in the FY 2016 Request is $1.75 million. CLB funding is requested at the FY 2015 Estimate and funding for REU supplements increases by $50,000.

Infrastructure

- Support for the NHERI increases by $500,000, to a total of $12.50 million. NHERI is the successor to NEES that received final year funding of $18.14 million in FY 2014. The reduction in overall operations costs from the previous facility follows recommendations from numerous studies that indicate a need for a leaner and more focused facilities program for earthquake engineering simulation. The reduction in facilities and operational costs enables additional investments to be made in research that addresses engineering strategies to design for and mitigate against multiple hazards including earthquakes, wind, storm surge, and combinations of these and other potential hazards.
- ENG continues support for infrastructure through investments in the NNCI at the FY 2015 Estimate.

DIVISION OF ELECTRICAL, COMMUNICATIONS, AND CYBER SYSTEMS (ECCS)

$119,240,000
+$8,810,000 / 8.0%

ECCS Funding
(Dollars in Millions)

	FY 2014[1] Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, ECCS	**$100.37**	**$110.43**	**$119.24**	**$8.81**	**8.0%**
Research	**94.33**	**104.24**	**113.00**	**8.76**	**8.4%**
CAREER	13.72	12.10	12.26	0.16	1.3%
Centers Funding (total)	5.93	5.79	5.11	-0.68	-11.7%
Nanoscale Science & Engineering Centers	0.89	0.79	0.11	-0.68	-86.1%
STC for Efficient Electronics	5.04	5.00	5.00	-	-
Education	**0.99**	**0.95**	**1.00**	**0.05**	**5.3%**
Infrastructure	**5.05**	**5.24**	**5.24**	**-**	**-**
National Nanotechnology Coordinated Infrastructure (NNCI)	-	5.24	5.24	-	-
National Nanotechnology Infrastructure Network	5.05	-	-	-	N/A

Totals may not add due to rounding.

[1] FY 2014 Actual obligations have been restated for the FY 2015 reorganization of the Office of Emerging Frontiers and Multidisciplinary Activities (EFMA) from Emerging Frontiers in Research and Innovation (EFRI) for comparability.

ECCS addresses fundamental research issues underlying electronic and photonic devices and component technologies, radio frequency through terahertz circuit integration, nanoelectronics, bioelectronics, energy (including alternate energy sources), power, smart-grid, controls, computation, networking, communications, control, sensing, robotics, and cyber–physical technologies. The division supports fundamental research of novel electronic and photonic devices, the integration of these devices into circuit and system environments, and the networking of intelligent systems at multiple scales for applications in energy, healthcare, disaster mitigation, telecommunications, environment, manufacturing, and other systems-related areas. ECCS research and education investments emphasize interdisciplinary collaboration and the convergence of technologies to take on major technological challenges for the next generation of innovative devices and systems.

In general, 72 percent of the ECCS portfolio is available for new research grants and 28 percent is available for continuing grants.

FY 2016 Summary
All funding decreases/increases represent change over the FY 2015 Estimate.

Research

- CAREER funding increases by $160,000, to a total of $12.26 million, in FY 2016. This increase is consistent with ECCS's emphasis on supporting early-career researchers.
- Initial support of $2.0 million will be provided in the area of Urban Science through a smart cities opportunity. In partnership with CISE and SBE, ENG will support activities focused on

multidisciplinary urban science and engineering, enabling effective integration of networked computing systems, physical devices, data sources, and infrastructure underlying smart cities.

- ECCS will continue support for the NSF-wide CIF21 activity, equal to the FY 2015 Estimate of $1.50 million, for research in advanced devices and systems directed towards computing, data storage, networking, and data management.
- The division's investment in the NRI ($2.50 million, unchanged from the FY 2015 Estimate) is part of the NSF-wide CEMMSS portfolio and will support the integration of electronic, mechanical, computing, sensing devices and systems, controls, and intelligent systems that enable ubiquitous, advanced robotics to be realized.
- In an ongoing collaboration with CISE, the division will support research on cyber–physical systems (CPS) totaling $4.50 million, unchanged from the FY 2015 Estimate. The ECCS investment is part of the NSF-wide CEMMSS portfolio and will be directed towards the integration of intelligent decision-making algorithms and hardware into physical systems.
- ECCS will increase support of multidisciplinary research in the optics and photonics area by $1.50 million, to a total of $41.50 million, with emphasis on nanoscale devices and systems. Applications in high-speed optical communications and environmental and biomedical research will be encouraged.
- ECCS will increase support for UtB research by $1.01 million, to a total of $2.25 million, for projects researching noninvasive brain imaging by sensing emitted electric and magnetic fields. Projects may develop novel high-sensitivity sensors and sensing algorithms to enhance spatial and temporal resolutions.
- The ECCS' investment in EARS remains $4.0 million, equal to the FY 2015 Estimate, and will support research on more efficient radio spectrum use and greatly improved low power, energy-conserving device technologies. Increased emphasis will be directed towards research of novel high-linearity transistors, devices, and circuits that will permit more efficient spectrum use, as well as research into new modulation techniques, circuits, and communications systems. Extension of the radio spectrum to bandwidth-rich higher frequencies will be enabled with research of new types of transistors, electronic devices, and circuits that can operate at these higher frequencies with enhanced efficiency. ECCS will also increase support on novel integrated antenna technologies and investigations of electromagnetic propagation in media where energy in electromagnetic signal is dissipated.
- ECCS funding of $5.0 million maintains support for the STC for Energy Efficient Electronics Science, led by the University of California at Berkeley and awarded in FY 2010.
- ECCS support for the NSEC program totals $110,000, a reduction of $680,000, as the program continues to sunset as planned.

Education

- ECCS contributes to a number of education and diversity activities, including REU and CLB. Total ECCS funding for these activities in the FY 2016 Request is $1.0 million. CLB funding is requested at the FY 2015 Estimate and funding for REU supplements increases by $50,000.

Infrastructure

- ENG maintains support for infrastructure through investments in the NNCI at the FY 2015 Estimate.

DIVISION OF ENGINEERING EDUCATION AND CENTERS (EEC) — $110,390,000 / -$7,100,000 / -6.0%

EEC Funding
(Dollars in Millions)

	FY 2014 Actual[1]	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, EEC	**$119.50**	**$117.49**	**$110.39**	**-$7.10**	**-6.0%**
Research	**92.92**	**93.96**	**85.37**	**-8.59**	**-9.1%**
CAREER	0.11	-	-	-	N/A
Centers Funding (total)	72.95	65.54	56.50	-9.04	-13.8%
Engineering Research Centers	70.06	64.50	56.50	-8.00	-12.4%
Nanoscale Science & Engineering Centers	1.25	1.04	-	-1.04	-100.0%
Science of Learning Centers	1.64	-	-	-	N/A
Education	**26.58**	**23.53**	**25.02**	**1.49**	**6.3%**

Totals may not add due to rounding.

[1] FY 2014 Actual obligations have been restated for the FY 2015 reorganization of the Office of Emerging Frontiers and Multidisciplinary Activities (EFMA) from Emerging Frontiers in Research and Innovation (EFRI) for comparability.

EEC integrates disciplinary basic research and education conducted in other divisions of ENG and across NSF into strategic frameworks critical for addressing societal grand challenges and promoting innovation. Research included in the EEC portfolio spans both the physical and life sciences and engineering, from nanostructured materials to new device concepts, subsystems, and systems. Applications range across a wide spectrum, including energy, medicine, telecommunications, nanoelectronics, manufacturing, civil infrastructure, the environment, computer networks, cybersecurity, and others. Also included are formal scholarly studies in engineering education and on how people learn.

The complex, integrative role of EEC requires a comprehensive infrastructure of people, equipment, and centers. Fresh, creative approaches to developing the engineering workforce are vital, as a lack of properly prepared engineers is a critical barrier to a healthy U.S. economy. EEC invests in faculty, graduate and undergraduate students, post-doctoral scholars, and K–12 teachers. As nontraditional students – e.g. part-time, delayed enrollment, veteran, etc. – comprise more than 70 percent of the general undergraduate population, EEC is defining unique alternative pathways for these students, especially veterans, to successfully earn degrees in engineering.

The programs in EEC are administratively managed within three categories: (1) Major Centers and Facilities; (2) Engineering Education Research; and (3) Engineering Career Development. The Major Centers and Facilities category is comprised of the signature ERC program, NSECs, and an SLC. They provide the framework for interdisciplinary research and education, development, and technology transfer in partnership with academia, industry, and government. The Engineering Education Research category advances new productive engineering pedagogy and learning strategies in traditional and non-traditional environments. This category also includes EEC's participation in the NSF-wide activity, IUSE, which integrates the agency's investments in undergraduate education. The Engineering Career Development category includes programs such as REU and Research Experiences for Teachers (RET).

In general, 18 percent of the EEC portfolio is available for new research grants. The remaining 82

percent funds continuing grants and cooperative agreements made in previous years. This high fraction of multi-year commitments is primarily a consequence of centers funding, which includes awards made as five-year cooperative agreements.

FY 2016 Summary
All funding decreases/increases represent change over the FY 2015 Estimate.

Research

- Support for the ERC program decreases by $8.0 million, to a total of $56.50 million. Decreased support will result in a reduction in the number of centers from 19 to 15 as the program is between competition years in FY 2016. The next class of ERCs will be funded in FY 2017. Funding and numbers of centers include three Nanosystems ERCs that were first supported in FY 2012.
- EEC funding of the directorate-supported SLC, the Center of Excellence for Learning in Education, Science, and Technology (CELEST), led by Boston University, ended as the center received final year funding in FY 2014 as planned.

Education

- In FY 2014, NSF adopted a comprehensive agency-wide framework – IUSE – that consolidates NSF's investments in undergraduate education. While the majority of funding for IUSE is provided through the Directorate for Education and Human Resources (EHR), other NSF directorates contribute directly to this effort, ensuring an enduring connection to established discipline-based activities and expertise. In FY 2016, ENG's consolidation of the Engineering Education Research and Nanotechnology Undergraduate Education programs into IUSE will be funded at $6.0 million, equal to the FY 2015 Estimate.
- Funding for the REU Sites program increases $250,000, to a total of $10.75 million in FY 2016. REU projects offer an opportunity to tap the Nation's diverse student talent pool and broaden participation in science and engineering. Research experience has been found to be one of the most effective avenues for attracting and retaining students in engineering and for preparing them for careers in this field.
- Funding for RET increases $100,000, to a total of $4.25 million. Over the past ten years, the RET in Engineering Sites program has provided K-12 teachers and community college faculty the opportunity to gain research experience in university laboratories. The professional development gained by the participants through this unique experience has enriched their performance in the classroom and their guidance of students toward engineering. The increase will support these participants in areas of national need such as sustainability, energy, manufacturing, robotics, and others.
- EEC will provide $1.40 million to support the agency's broadening participation pilot NSF INCLUDES.
- Support of the NRT program decreases by $260,000, to a total of $2.59 million. ENG will continue to participate in NRT, a modernization of the IGERT program. The FY 2016 decrease is a continuing reduction in the remaining commitments to IGERT awards.
- EEC support for the NSEC program ends as the final center supported by the division receives its last year funding in FY 2015 as planned.

DIVISION OF INDUSTRIAL INNOVATION AND PARTNERSHIPS (IIP) — $248,110,000 / +$21,130,000 / 9.3%

IIP Funding
(Dollars in Millions)

	FY 2014[1] Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, IIP	**$205.99**	**$226.98**	**$248.11**	**$21.13**	**9.3%**
Research	**205.79**	**226.83**	**247.96**	**21.13**	**9.3%**
SBIR/STTR	159.99	177.11	194.36	17.25	9.7%
Education	**0.20**	**0.15**	**0.15**	**-**	**-**

Totals may not add due to rounding.

[1] FY 2014 Actual obligations have been restated for the FY 2015 reorganization of the Office of Emerging Frontiers and Multidisciplinary Activities (EFMA) from Emerging Frontiers in Research and Innovation (EFRI) for comparability.

IIP contributes to the NSF innovation ecosystem by: (1) supporting innovation research that builds on fundamental research discoveries that exhibit potential for societal and economic impact; (2) encouraging research partnerships between academia and industry; and (3) offering hands-on experience in the innovation process to current and future entrepreneurs and innovators.

IIP is home to two federal small business research programs, the Small Business Innovation Research (SBIR) program and the Small Business Technology Transfer (STTR) program. These programs support innovation research that leverages academic research findings and builds partnerships among small businesses, academia, large companies, and/or other stakeholders with the goal of achieving technology commercialization and enabling new products, processes, or services. Technology topics draw upon the breadth of NSF scientific and engineering research disciplines and are aligned along national and societal priorities.

IIP supports academic research through three research programs: the Industry/University Cooperative Research Center (I/UCRC) program, the Partnership for Innovation (PFI) program, and the Grant Opportunities for Academic Liaison with Industry (GOALI) program. These programs aim to stimulate academia-industry partnerships, leverage industrial support, accelerate technology commercialization, and empower future generations in science and engineering. University grantees in these programs collaborate with industry to create enabling technologies that meet national needs, such as managing the electrical power system, improving manufacturing and biological processing, and supporting new information and communications technologies.

The division also administers, and is a strong intellectual contributor to, the I-Corps™ program. The NSF I-Corps™ connects NSF-funded science and engineering research with the technological, entrepreneurial, and business communities, and fosters a national innovation ecosystem that links scientific discovery with technology development, societal needs, and economic opportunities.

In general, 93 percent of the IIP portfolio is available for new research grants and seven percent is available for continuing grants.

FY 2016 Summary
All funding decreases/increases represent change over the FY 2015 Estimate.

Research

- Funding for SBIR/STTR increases by $17.25 million, to a total of $194.36 million, consistent with the levels specified in the SBIR/STTR Reauthorization Act of 2011 (P.L 112-81), which stipulates 3.0 percent and 0.45 percent of NSF's FY 2016 extramural research funding be allocated to the SBIR and STTR programs, respectively. Increased support for SBIR/STTR will (1) provide more resources to the small business community to carry on cutting-edge, high-risk, and high-impact research projects; and (2) provide an opportunity for greater collaboration with the disciplinary divisions across NSF in the spirit of catalyzing technology commercialization of discovery research.
- Funding for the PFI program increases $500,000, to a total of $22.0 million. The PFI program is an umbrella for two complementary components. The Building Innovation Capacity (BIC) component supports academic-industry partnerships, which are led by an interdisciplinary academic research team with at least one industry partner, to collaborate in building technological, human and service system innovation capacity and to further basic research toward market-accepted innovations. These partnerships focus on the integration of technologies inspired by breakthrough discoveries into a specified human-centered smart service system with the potential to achieve transformational change in an existing service system or to spur an entirely new service system. The Accelerating Innovation Research (AIR) component is designed to enable research discoveries to be translated onto a path toward commercial reality while engaging faculty and students in entrepreneurial and market-oriented thinking, leveraging the prior investments NSF has made, and providing NSF-funded research alliances the opportunity to develop academic-based innovation ecosystems.
- Funding for I-Corps™ increases by $2.38 million, to a total of $13.0 million, to provide greater resources that will help determine the readiness to commercialize technologies built on previously or currently NSF-funded basic research projects.
- Funding for I/UCRC increases $500,000, to a total of $12.50 million. Support will emphasize topics related to advanced manufacturing, clean energy, and cyberinfrastructure, in line with NSF investments in CEMMSS and CIF21. Funding will also support REU, which will further enhance the educational impact of I/UCRC and prepare students for innovation leadership in a globally competitive marketplace through opportunities to work closely with industry.
- IIP's support for GOALI increases by $500,000, to a total of $6.25 million. The program promotes university-industry partnerships by making project funds or fellowships/traineeships available to support an eclectic mix of industry-university linkages across the Foundation.

Education

- Support for the REU program, $150,000, remains the same as the FY 2015 Estimate.

OFFICE OF EMERGING FRONTIERS AND MULTIDISCIPLINARY ACTIVITIES (EFMA) **$56,490,000**
+$6,420,000 / 12.8%

EFMA Funding
(Dollars in Millions)

	FY 2014[1] Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Percent
Total, EFMA	**$44.27**	**$50.07**	**$56.49**	**$6.42**	**12.8%**
Research	**35.82**	**41.71**	**48.13**	**6.42**	**15.4%**
Education	**3.41**	**3.36**	**3.36**	**-**	**-**
Infrastructure	**5.04**	**5.00**	**5.00**	**-**	**-**
Cornell High Energy Synchrotron Source (CHESS)	5.04	5.00	5.00	-	-

Totals may not add due to rounding.

[1] The Office of Emerging Frontiers and Multidisciplinary Activities (EFMA) is the reorganized form of Emerging Frontiers in Research and Innovation (EFRI), beginning in FY 2015. FY 2014 Actual obligations have been restated for comparability.

EFMA strategically pursues and funds projects in important emerging areas in a timely manner. The office also provides support to multidisciplinary education programs such as ADVANCE and REU. Additionally, EFMA is the home to ENG's annual operations support of the Cornell High Energy Synchrotron Source (CHESS) facility. The largest activity in EFMA is the Emerging Frontier in Research and Innovation (EFRI) program.

Each year EFRI recommends, prioritizes, and funds interdisciplinary topics at the frontiers of engineering research and education that have the potential for transformative impacts on national needs and/or grand challenges. Technological innovations have given rise to new industries, expanded access to quality healthcare, and fueled national prosperity even as global competition has grown. To help ensure the nation's continued success, EFRI provides critical, strategic support of fundamental discovery, particularly in areas that may lead to breakthrough technologies and strengthen the economy's technical underpinnings. EFRI will have the necessary flexibility to target long-term challenges, while retaining the ability and agility to adapt as new challenges demand.

EFRI encourages the engineering community to come forward with new and paradigm-shifting proposals at the interface of disciplines and fields in important emerging areas. Their ideas and discoveries may potentially lead to new research areas for NSF and other agencies, new industries or capabilities that result in a leadership position for the country, and/or significant progress on a recognized national need or grand challenge.

Recent EFRI topics have included areas such as: integrated processes and systems designed to make U.S. infrastructures more resilient to disasters and unexpected events; sustainable energy sources; advances in robotics; and flexible technologies and regenerative engineering for healthcare. In FY 2012 and FY 2013, EFRI invested in three topic areas: Flexible Bioelectronics Systems (BioFlex); Origami Design for the Integration of Self-assembling Systems for Engineering Innovation (ODISSEI); and Photosynthetic Biorefineries (PSBR). These were developed in close collaboration with the Directorates for Biological Sciences (BIO) and MPS. The results from these investigations hold the potential to enable new biological energy sources and better protection for the environment, and human health, including novel

cancer screening technologies, and innovations in many areas, ranging from surgical instruments to adaptive aircraft structures and reconfigurable robots. In FY 2015, EFRI is investing in an important topic area for the second consecutive year on 2-Dimensional Advance Materials Research and Engineering (2-DARE). This topic is being managed jointly by ENG and MPS. The rapid and recent advances in graphene, a single sheet of carbon atoms arranged in a two-dimensional (2D) honeycomb crystal lattice, have raised questions for other examples of 2D materials that might have distinct and useful properties. The EFRI 2-DARE topic promotes the exploration of the exciting prospects of 2D atomic layers and devices in the wide range of compositions of 2D-layered materials beyond graphene that can stimulate technologically significant applications in the coming years.

EFRI coordinates its interdisciplinary activities both within NSF and with relevant federal agencies. The Department of Energy (DOE) and the Environmental Protection Agency (EPA) have co-funded some of the EFRI projects in sustainable energy and environmental design. The Air Force Office of Scientific Research (AFOSR) entered into a five-year Memorandum of Understanding (MOU) with NSF in FY 2012 to collaborate and help support projects of mutual interest. AFOSR participated in reviews of ODISSEI research projects, and is collaborating on the second year of the FY 2015 2-DARE competition currently underway.

In general, 90 percent of the EFRI portfolio is available for new research grants and 10 percent supports continuing increments for grants made in previous years.

FY 2016 Summary
All funding decreases/increases represent change over the FY 2015 Estimate.

Research

- FY 2016 EFRI support increases by $1.50 million, to a total of $32.50 million, and will provide support for up to 16 interdisciplinary team projects aimed at addressing national challenges such as renewable energy, advanced manufacturing, and critical and resilient infrastructure systems and processes.
- An increase of $4.92 million, to a total of $15.63 million, is provided to support new and ongoing NSF-wide multidisciplinary investments and other important national priorities.

Education

- EFMA support for the ADVANCE and REU programs are maintained at the FY 2015 Estimate of $3.26 million and $100,000 respectively.

Infrastructure

- EFMA continues support for infrastructure through investments in the CHESS facility at the FY 2015 Estimate.

DIRECTORATE FOR GEOSCIENCES (GEO) $1,365,410,000
+$61,020,000 / 4.7%

GEO Funding

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Atmospheric and Geospace Sciences (AGS)	$250.85	$251.15	$262.88	$11.73	4.7%
Earth Sciences (EAR)	177.81	177.20	188.21	11.01	6.2%
Integrative and Collaborative Education and Research (ICER)	83.53	83.74	95.20	11.46	13.7%
Ocean Science (OCE)	356.27	355.95	369.61	13.66	3.8%
Polar Programs (PLR)	452.87	436.35	449.51	13.16	3.0%
U.S. Antarctic Logistical Support (USALS)	*[68.94]*	*[67.52]*	*[67.52]*	-	-
Total, GEO	**$1,321.32**	**$1,304.39**	**$1,365.41**	**$61.02**	**4.7%**

Totals may not add due to rounding.

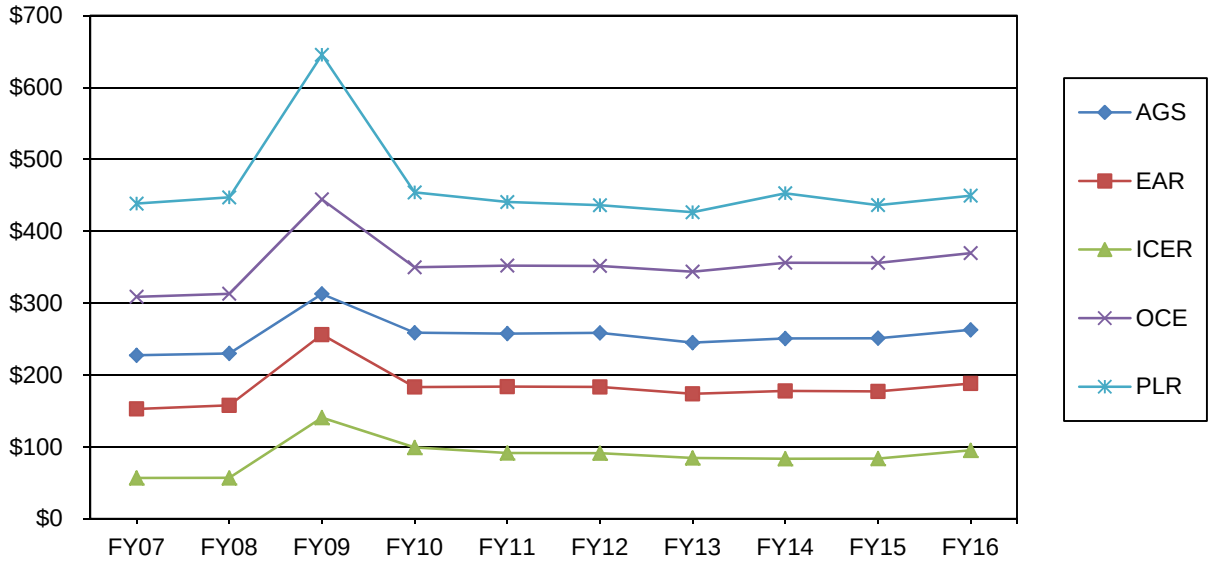
About GEO

GEO supports basic research that advances the frontiers of knowledge and drives technological innovation while improving our understanding of the many processes that affect the global environment. These processes include the planetary water cycle, geologic interactions that cross the land-ocean interface, and the behavior of ice sheets. Lives are saved and property is preserved through better prediction and understanding of natural environmental hazards such as earthquakes, tornados, hurricanes, tsunamis, drought, and solar storms. Basic research supported by GEO enables preparation for and subsequent mitigation of, or adaptation to, the effects of these and other disruptive natural events. Support is provided for interdisciplinary studies that contribute directly to national research priorities such as: mitigating the impacts of hazardous events; developing and deploying integrated ocean observing capabilities to support ecosystem-based management; and understanding future availability and distribution of fresh water. Another focus is understanding the Earth's polar regions – research that spans not only atmospheric, earth, and ocean processes, but other NSF-supported disciplines.

As the primary U.S. supporter of fundamental research in the polar regions, GEO provides interagency leadership for U.S. polar activities. In the Arctic, NSF helps coordinate research planning as directed by the Arctic Research Policy Act of 1984. The NSF Director chairs the Interagency Arctic Research Policy Committee created for this purpose, which is now a component of the President's National Science and Technology Council (NSTC). In the Antarctic, per Presidential Memorandum 6646, GEO manages all U.S. activities as a single, integrated program, making Antarctic research possible for scientists supported by NSF and by other U.S. federal agencies. The latter include the National Aeronautics and Space Administration (NASA), the National Oceanic and Atmospheric Administration (NOAA), the U.S. Geological Survey (USGS), the Smithsonian Institution, and the Department of Energy. The U.S. Antarctic Program research activity funded by NSF also supports leadership by the U.S. Department of State in the governance of the continent and Southern Ocean under the aegis of the Antarctic Treaty.

GEO provides about 61 percent of the federal funding for basic research at academic institutions in the geosciences.

GEO Subactivity Funding
(Dollars in Millions)



FY 2009 funding reflects both the FY 2009 omnibus appropriation and funding provided through the American Recovery and Reinvestment Act of 2009 (P.L. 111-5).

FY 2016 Summary by Division

- AGS's FY 2016 Request emphasizes support for two new NSF-wide emphasis areas: 1) the Risk and Resilience activity through PREEVENTS (Prediction of and Resilience against Extreme Events), and 2) the Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS) investment. Support continues for the NSF-wide Science, Engineering, and Education for Sustainability (SEES) investment as it ramps down. AGS priorities include maintaining support for disciplinary and interdisciplinary research activities and the observational infrastructure required to conduct modern research, including overseeing operation of the National Center for Atmospheric Research (NCAR)-Wyoming Supercomputing Center.

- EAR's FY 2016 Request is focused on support for PREEVENTS and INFEWS. Supporting SEES, maintaining support for disciplinary and interdisciplinary research activities, and the observational infrastructure required to conduct modern research also remain priorities.

- ICER's FY 2016 Request includes support for PREEVENTS and INFEWS. Support will continue for priority areas such as Cyberinfrastructure Framework for 21st Century Science, Engineering, and Education (CIF21) and SEES. Funding for Improving Undergraduate STEM Education (IUSE), led by the Directorate for Education and Human Resources (EHR), is reduced and funds are redirected to the new NSF-wide Inclusion across the Nation of Communities of Learners that have been Underrepresented for Diversity in Engineering and Science (NSF INCLUDES) activity as well as Research Experiences for Undergraduates (REU). GEO is also initiating through the ICER division a new activity to support mid-scale research infrastructure, which will address those projects that are above the ceiling for the Major Research Infrastructure (MRI) program but below the threshold for Major Research Equipment and Facilities Construction (MREFC) consideration. ICER will also

provide some support for the operations and maintenance of the Ocean Observatories Initiative (OOI), enabling OCE to maintain a strong research portfolio.

- OCE's FY 2016 Request includes support for PREEVENTS and INFEWS. It also supports SEES. OCE is strongly supporting the President's Executive Order establishing a National Ocean Policy (NOP) through enablement of research, education, and infrastructure. OCE continues to support OOI. OCE is continuing to invest in research infrastructure and planning for potential new Regional Class Research Vessels (RCRV).

- PLR's FY 2016 Request is focused on maintaining strong disciplinary programs; targeted basic research in cross-foundation and interagency priorities; and supporting and improving the efficiency of critical facilities that enable research in both polar regions, including planning to realize NSF's long-term vision for continued U.S. presence in Antarctica. Support is also provided for PREEVENTS and INFEWS.

Major Investments

GEO Major Investments

(Dollars in Millions)

Area of Investment	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
CAREER	$18.47	$15.64	$16.65	$1.01	6.5%
CIF21	15.25	11.00	14.21	3.21	29.2%
I-Corps™	1.09	1.38	0.60	-0.78	-56.5%
NSF INCLUDES	-	-	2.44	2.44	N/A
INFEWS	-	-	14.78	14.78	N/A
INSPIRE	0.69	2.17	2.17	-	-
IUSE	-	10.90	6.00	-4.90	-45.0%
Mid-Scale Infrastructure	-	-	9.31	9.31	N/A
NRT[1]	2.21	6.63	4.43	-2.20	-33.2%
Risk and Resilience	-	-	23.50	23.50	N/A
SEES	68.00	59.00	34.00	-25.00	-42.4%

Major investments may have funding overlap and thus should not be summed.

[1] Outyear commitments for Integrative Graduate Education and Research Traineeship (IGERT) are included in the NRT line and are $2.21 million in FY 2014, $2.04 million in FY 2015, and $0.61 million in FY 2016.

- CAREER: GEO support for the CAREER program will increase 6.5 percent, from $15.64 million in the FY 2015 Estimate, to $16.65 million in the FY 2016 Request, reflecting GEO's commitment to supporting the next generation of scientists.

- CIF21: GEO's investment will increase by nearly 30 percent in FY 2016, from a FY 2015 Estimate level of $11.0 million to a FY 2016 Request level of $14.21 million in FY 2016. The increase is largely related to GEO's participation in the new Data Science Pilots activity that will be initiated in FY 2016.

- I-Corps™: GEO support decreases relative to FY 2015 Estimate to a total of $600,000, reflecting the end of GEO direct support for I-Corps™ Sites. GEO continues to support I-Corps™ Nodes.

- NSF INCLUDES: In FY 2016, NSF emphasizes a new program, NSF INCLUDES, which aims to promote broader participation in the sciences. GEO support totals $2.44 million in FY 2016.

- INFEWS: In FY 2016, NSF is building a new interdisciplinary investment to study the food-energy-water nexus, Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS). Initial support for this activity in FY 2016 totals $14.78 million.

- INSPIRE: GEO will maintain an investment of $2.17 million in INSPIRE.

- IUSE: Support for the NSF-wide IUSE (Improving Undergraduate STEM Education) activity decreases by $4.90 million, to a total of $6.0 million. Funds are redirected to Research Experiences for Undergraduates (REU) and NSF INCLUDES.

- Mid-Scale Infrastructure: Support for this new activity will enable GEO to invest in emerging infrastructure beyond the scope of the MRI program, but smaller than what is typically funded through NSF's MREFC account. GEO funding is $9.31 million in FY 2016.

- NSF Research Traineeship (NRT): GEO will continue to fund STEM graduate students in areas of national priority and support the development of transformative and scalable models for STEM graduate education.

- Risk and Resilience: In FY 2016, NSF is initiating a new activity to enhance national risk and resilience to hazardous events. GEO plays a key role in advancing understanding of natural hazards such as tornados, hurricanes, earthquakes, and disruptive space weather events, and is investing $23.50 million in PREEVENTS in FY 2016.

- SEES: SEES programs began a planned ramp-down in FY 2015, and in FY 2016, this phase-out will continue. GEO support for SEES decreases by $25.0 million, to a total of $34.0 million in FY 2016. Funds are largely being reinvested in the Risk and Resilience activity and INFEWS.

GEO Funding for Centers Programs and Facilities

GEO Funding for Centers Programs

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, Centers Programs	**$14.32**	**$10.32**	**$5.00**	**-$5.32**	**-51.6%**
Science & Techology Centers (AGS, OCE, PLR)	14.32	10.32	5.00	-5.32	-51.6%

Totals may not add due to rounding.

For detailed information on individual centers, please see the NSF-Wide Investments chapter.

- FY 2016 sees the planned retirement of two Science and Technology Centers (STC): the Center for Multiscale Atmospheric Processes and the Center for Coastal Margin Observation and Prediction. In

OCE, support continues for the Center for Dark Energy Biosphere Investigations at a level of $5.0 million.

GEO Funding for Facilities

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, Facilities	**$633.94**	**$629.35**	**$641.18**	**$11.83**	**1.9%**
Academic Research Fleet[1] (OCE)	84.86	87.00	88.00	1.00	1.1%
Arctic Research Support and Logistics (PLR)	44.08	38.64	40.27	1.63	4.2%
Arecibo Observatory (AGS)	3.50	4.00	4.10	0.10	2.5%
Geodesy Advancing Geosciences and EarthScope (GAGE)	11.58	11.58	12.33	0.75	6.5%
IceCube Neutrino Observatory (PLR)	3.45	3.45	3.45	-	-
International Ocean Discovery Program (OCE)	50.00	48.00	48.00	-	-
National Center for Atmospheric Research (AGS)	96.60	98.20	99.00	0.80	0.8%
National Nanotechnology Coordinated Infrastructure (ICER)	-	0.30	0.30	-	-
National Nanotechnology Infrastructure Network (ICER)	0.30	-	-	-	N/A
Ocean Observatories Initiative (OCE and ICER)	49.30	55.00	55.00	-	-
Seismological Facilities for the Advancement of Geosciences and EarthScope (EAR)	24.35	24.35	25.10	0.75	3.1%
U.S. Antarctic Facilities and Logistics (PLR)	196.99	191.31	198.11	6.80	3.6%
U.S. Antarctic Logistical Support (PLR)	68.94	67.52	67.52	-	-

Totals may not add due to rounding.

[1]Academic Research Fleet includes funding for pre-construction planning for Regional Class Research Vessels: $1.86 million in FY 2014, $2.0 million in FY 2015, and $3.0 million in FY 2016.

For detailed information on individual facilities, please see the Facilities chapter.

- Support for the Academic Research Fleet increases from $87.0 million in FY 2015 to $88.0 million in FY 2016, reflecting the ramp-up in planning for the possible construction of up to three Regional Class Research Vessels.

- Arctic Research Support and Logistics increases by $1.63 million to a total of $40.27 million in FY 2016, reflecting higher operating expenses.

- Arecibo Observatory support increases $100,000 to $4.10 million in FY 2016. The Directorate for Mathematical and Physical Sciences (MPS) leads this activity.

- Support for Geodesy Advancing Geosciences and EarthScope (GAGE) increases from a FY 2015 level of $11.58 million to $12.33 million in FY 2016. This increase is required for the facility to continue supporting the user community at current levels.

- The National Center for Atmospheric Research (NCAR) will increase by $800,000 to a total of $99.0 million in FY 2016. The increase will allow deferred maintenance needs on NSF-owned assets to be addressed.

- Support for Seismological Facilities for the Advancement of Geosciences and EarthScope (SAGE) increases from a FY 2015 level of $24.35 million to $25.10 million in FY 2016. This increase is required for the facility to continue supporting the user community at current levels.

- U.S. Antarctic Facilities and Logistics support increases to $198.11 million in FY 2016. This includes an additional $1.0 million, to a total of $3.0 million, for the Antarctic Infrastructure Modernization for Science (AIMS) preconstruction planning project. The majority of the $6.80 million increase above the FY 2015 level is associated with support for increased science demands and mandatory military pay raises.

Summary and Funding Profile

GEO supports investment in disciplinary and interdisciplinary research and education as well as research infrastructure such as the National Center for Atmospheric Research (NCAR), the Academic Research Fleet, and research stations in the Arctic and Antarctic.

In FY 2016, the number of research grant proposals is expected to stay about the same as in FY 2015 and GEO expects to award about 1,600 research grants. Average annual award size and duration are not expected to materially fluctuate in FY 2014 through FY 2016.

Operations and maintenance funding for GEO-supported user facilities and infrastructure comprises about 52 percent of GEO's FY 2016 Request. GEO has increased operations budgets for some facilities in FY 2016 in order to maintain current operational capacity.

GEO Funding Profile

	FY 2014 Actual Estimate	FY 2015 Estimate	FY 2016 Estimate
Statistics for Competitive Awards:			
Number of Proposals	5,797	6,100	6,100
Number of New Awards	1,494	1,600	1,600
Funding Rate	26%	26%	26%
Statistics for Research Grants:			
Number of Research Grant Proposals	5,306	5,600	5,600
Number of Research Grants	1,268	1,350	1,350
Funding Rate	24%	24%	24%
Median Annualized Award Size	$141,121	$145,000	$145,000
Average Annualized Award Size	$200,471	$195,000	$210,000
Average Award Duration, in years	2.7	2.7	2.8

Program Monitoring and Evaluation

- External Program Evaluations and Studies: In January 2015, OCE received a Decadal Survey of

Ocean Sciences from the Ocean Studies Board of the National Research Council. This survey:

- Summarized ocean science advancements from the past decade;
- Identified ocean science priorities for the next decade;
- Analyzed the ability of current research infrastructure to address those priorities;
- Recommended an infrastructure portfolio that is needed to advance those priorities; and
- Assessed opportunities for NSF to meet research priorities by complementing ocean science research conducted by other federal agencies.

Committees of Visitors (COV):

- In 2014, COVs reviewed the AGS Geospace Section, EAR, and the OCE Integrative Programs Section. The COV reports were presented to the GEO Advisory Committee at their October 2014 meeting. While broadly complimentary of the work of the reviewed activities, some recommendations for improvement were made. Recommendations included suggestions for improved efficiency in the use of infrastructure, streamlining programmatic structure to better assist the research community, and to continue efforts to educate proposers on NSF's expectations with regard to broader impacts.
- In 2015, COVs will be held to review Ocean Research and Education programs and the National Center for Atmospheric Research (NCAR) and Facilities Section within AGS.
- In 2016, COVs will review the Atmosphere Section in AGS, and PLR's Antarctic Sciences, Antarctic Infrastructure, and Arctic Sciences Sections.

Workshops:

- With NSF and NASA funding, the Interagency Ocean Observation Committee's Biological Integration and Observation Task Team of 35 participants with a wide range of expertise from the ocean observing community conducted a workshop in November 2014 to identify and prioritize crosscutting biological and ecosystem observation needs.
- To encourage interactions between the Hydrologic Science and Physical and Dynamic Meteorology research communities in advancing this critical research, a community workshop was held in September 2014.

The Performance chapter provides details regarding the periodic reviews of programs and portfolios of programs by external Committees of Visitors and directorate Advisory Committees. Please see this chapter for additional information.

Number of People Involved in GEO Activities

	FY 2014 Actual Estimate	FY 2015 Estimate	FY 2016 Estimate
Senior Researchers	5,316	5,700	5,600
Other Professionals	3,500	3,200	3,700
Postdoctorates	661	600	700
Graduate Students	2,556	2,800	2,700
Undergraduate Students	3,012	2,400	3,200
Total Number of People	**15,045**	**14,700**	**15,900**

DIVISION OF ATMOSPHERIC AND GEOSPACE SCIENCES (AGS) — $262,880,000 +$11,730,000 / 4.7%

AGS Funding

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, AGS	**$250.85**	**$251.15**	**$262.88**	**$11.73**	**4.7%**
Research	**122.42**	**123.39**	**133.28**	**9.89**	**8.0%**
CAREER	8.43	6.21	6.67	0.46	7.4%
Centers Funding (total)	3.32	2.66	-	-2.66	-100.0%
STC: Multiscale Modeling of Atmospheric Processes	3.32	2.66	-	-2.66	-100.0%
Education	**4.14**	**2.54**	**3.00**	**0.46**	**18.1%**
Infrastructure	**124.29**	**125.22**	**126.60**	**1.38**	**1.1%**
Arecibo Observatory	3.50	4.00	4.10	0.10	2.5%
National Center for Atmospheric Research (NCAR)	96.60	98.20	99.00	0.80	0.8%
Research Resources	24.19	23.02	23.50	0.48	2.1%

Totals may not add due to rounding.

The mission of AGS is to extend intellectual frontiers in atmospheric and geospace sciences by making responsible investments in fundamental research, technology development, and education that enable discoveries; nurture a vibrant, diverse scientific workforce; and help attain a prosperous and sustainable future. AGS supports activities to further understanding of the dynamics of the Sun and the physics, chemistry, and dynamics of the Earth's atmosphere and near-space environment. AGS provides support for: 1) basic science projects and 2) the acquisition, maintenance, and operation of observational and cyber-infrastructure facilities and services that enable and support modern day atmospheric and geospace science research activities. Although the majority of AGS support is through traditional "individual investigator" merit reviewed, multi-year grants, the division also supports small-scale, limited duration exploratory research projects; collaborative or multi-investigator group projects focusing on a particular project, subject, or activity; large center or center-like projects; and funding for the research conducted at facilities provided by NSF's National Center for Atmospheric Research (NCAR), which extends and enhances research at universities. More information on NCAR is available in the Facilities chapter. The division will continue support in key areas of fundamental atmospheric and geospace science, including efforts to improve understanding of the dynamics, predictability, and impacts of extreme atmospheric and space weather events, and development of fundamental knowledge to support preparedness and improve adaptation to short and long-term variability in weather.

Recognizing the close interplay between the division's support for science and the provision of facilities to support that science, AGS seeks to properly balance such support. Approximately 50 percent of the annual budget of AGS is used to support observational and computational facilities, as well as NCAR, a Federally Funded Research and Development Center, and the Arecibo Observatory, which is co-funded with the Division of Astronomy (AST) within the Directorate for Mathematical and Physical Sciences (MPS). The remaining half of the AGS budget is for individual, small group, and center-like research

grants. In general, of the 50 percent of the AGS budget available for research grants, about 30 percent is available for new research grants. The remaining portion of the AGS budget funds continuing grants made in previous years.

FY 2016 Summary

All funding decreases/increases represent change over the FY 2015 Estimate.

Research

- Support for the AGS disciplinary and interdisciplinary research programs is maintained to fund basic research into understanding weather and precipitation variability, and extreme atmospheric and space weather phenomena.
- AGS will support NSF's INFEWS activity at a level of $2.50 million, new in 2016.
- An NSF-wide thrust on Risk and Resilience research, new in FY 2016, will be supported at $5.25 million through GEO's PREEVENTS activity.
- Investments in the SEES portfolio decrease by $3.0 million, to $10.0 million, as the SEES program focused on earth system modeling ramps down.
- $500,000 is provided for the Integrated NSF Support Promoting Interdisciplinary Research and Education (INSPIRE) program.
- Support for early-career researchers remains an AGS priority. The division increases its support for CAREER grants to a total of $6.67 million. This funding is consistent with GEO and AGS objectives.
- Funding for the Center for Multi-scale Modeling of Atmospheric Processes (CMMAP) has come to a close, reflecting the planned sunsetting of this Class of 2006 STC.

Education

- The education portfolio increases to $3.0 million in FY 2016, reflecting the division's commitment to the Research Experiences for Undergraduates (REU) program and support for postdoctoral fellows.

Infrastructure

- Funding for the Arecibo Observatory will increase $100,000, to a total of $4.10 million, equivalent to the level of co-funding support from MPS/AST.
- NCAR support is increased by $800,000, to a total of $99.0 million, to fund needed research infrastructure for advancing the understanding of high-impact atmospheric and space weather hazards.
- Research Resources are allocated $23.50 million to support the deployment of lower atmosphere observing facilities and to support access to data and software for the research community.

DIVISION OF EARTH SCIENCES (EAR) $188,210,000
+$11,010,000 / 6.2%

EAR Funding
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, EAR	**$177.81**	**$177.20**	**$188.21**	**$11.01**	**6.2%**
Research	**117.09**	**114.32**	**122.58**	**8.26**	**7.2%**
CAREER	6.87	5.50	5.87	0.37	6.7%
Education	**4.29**	**4.95**	**5.45**	**0.50**	**10.1%**
Infrastructure	**56.43**	**57.93**	**60.18**	**2.25**	**3.9%**
Geodesy Advancing Geosciences and EarthScope (GAGE)	11.58	11.58	12.33	0.75	6.5%
Seismological Facilities for the Advancement of Geosciences and EarthScope (SAGE)	24.35	24.35	25.10	0.75	3.1%
Research Resources	20.50	22.00	22.75	0.75	3.4%

Totals may not add due to rounding.

EAR supports fundamental research into the structure, composition, and evolution of the Earth, and the life it has sustained over the four and a half billion years of Earth history. The results of this research will lead to a better understanding of Earth's changing environment (past, present, and future), the natural distribution of its water, food, and energy resources, and provide methods for predicting and mitigating the effects of geologic hazards such as earthquakes, volcanic eruptions, floods, and landslides.

Through its Surface Earth Processes section, EAR supports research in geomorphology and land use, hydrologic science, geobiology and low temperature geochemistry, and sedimentary geology and paleobiology. The division's Deep Earth Processes section maintains programs in geophysics, tectonics, petrology and geochemistry, and integrated earth systems. In addition to these fundamental research programs, EAR has an Instrumentation and Facilities program that supports community-based, shared-use facilities and the acquisition and development of instrumentation by individual investigators; EarthScope, a large-scale facility with an associated science program focused on studying the structure and tectonics of the North American continent; and an education program that funds a number of activities to attract and support students and young investigators to the field of earth science.

Approximately 68 percent of EAR's budget is used to support individuals and small groups of researchers, while about 32 percent of the budget goes to instrumentation and facilities. The two largest facilities supported by EAR are Seismological Facilities for the Advancement of Geosciences and EarthScope (SAGE) and Geodesy Advancing Geosciences and EarthScope (GAGE). In general, 38 percent of the EAR portfolio is available for new research grants. The remaining 62 percent is utilized to support grants made in prior years, along with the research infrastructure necessary for the conduct of cutting-edge research on a variety of earth science topics.

FY 2016 Summary

All funding decreases/increases represent change over the FY 2015 Estimate.

Research

- EAR will support INFEWS at a level of $6.50 million, new in 2016.
- EAR will continue its participation in SEES at a level of $1.50 million, a reduction of $7.0 million below FY 2015.
- An NSF-wide thrust on Risk and Resilience research, new in FY 2016, will be supported at $5.25 million through GEO's PREEVENTS activity.
- In FY 2016, EAR's support for the INSPIRE program will be $500,000.
- CAREER funding will be supported at a level of $5.87 million, an increase of $370,000 over FY 2015, reflecting EAR's continued commitment to supporting early career investigators.

Education

- EAR's support for education activities in FY 2016 will be $5.45 million, an increase of $500,000 over FY 2015. Research Experiences for Undergraduates (REU) sites will increase from $1.50 million to $1.74 million, and support for EAR Postdoctoral Fellowships will increase from $1.70 million to $1.96 million, reflecting EAR's commitment to workforce development.

Infrastructure

- SAGE and GAGE will increase funding by 3.1 and 6.5 percent, respectively, allowing these key facilities to continue to serve growing communities of researchers.
- Increased funding of $750,000 to a total of $22.75 million will enable EAR's Instrumentation and Facilities Program to provide more support for multi-user regional and national facilities.

DIVISION OF INTEGRATIVE AND COLLABORATIVE EDUCATION AND RESEARCH (ICER) **$95,200,000**
+$11,460,000 / 13.7%

ICER Funding
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, ICER	**$83.53**	**$83.74**	**$95.20**	**$11.46**	**13.7%**
Research	**76.36**	**50.80**	**55.12**	**4.32**	**8.5%**
CAREER	0.09	0.40	0.40		
Education	**6.87**	**18.64**	**16.47**	**-2.17**	**-11.6%**
Infrastructure	**0.30**	**14.30**	**23.61**	**9.31**	**65.1%**
National Nanotechnology Coordinated Infrastructure (NNCI)	-	0.30	0.30	-	-
National Nanotechnology Infrastructure Network (NNIN)	0.30	-	-	-	N/A
Ocean Observatories Initiative (OOI)	-	14.00	14.00	-	-
Mid-Scale Research Infrastructure	-	-	9.31	9.31	N/A

Totals may not add due to rounding.

ICER supports novel, complex, or partnership projects in both research and education. These investments cut across traditional boundaries within the geosciences, encouraging interdisciplinary activities and responding directly to critical needs of the entire geoscience community. ICER's principal goals are to develop innovative means to initiate and support geoscience education, attract underrepresented groups to careers in the geosciences, foster the interchange of scientific information nationally and internationally, and to join with other parts of NSF in major integrative research and education efforts. In FY 2016, the division will make strategic investments in new multidisciplinary research areas, international activities, education, diversity, and human resource development.

In general, 43 percent of the ICER portfolio is available for new research grants. The remaining 57 percent supporting continuing grants made in previous years.

FY 2016 Summary

All funding decreases/increases represent change over the FY 2015 Estimate.

Research

- ICER will support NSF's INFEWS investment at a level of $3.78 million, new in 2016.
- A new NSF-wide thrust on Risk and Resilience research will be supported through GEO's PREEVENTS activity at $3.0 million.
- ICER will support activities in SEES totaling $10.0 million in FY 2016, a reduction of $5.0 million, reflecting the phasing out of this activity. Funds will be redirected to INFEWS and Risk and Resilience.
- ICER supports a varied portfolio of international collaborative activities. In FY 2016, this will total $6.50 million, and emphasize collaborative research across the Americas and activities sponsored by

the Belmont Forum, a group of the world's leading and emerging funding agencies focused on providing international, multi-lateral research opportunities for sustainability.

Education

- In FY 2016, GEO is decreasing support for the NSF-wide Improving Undergraduate STEM Education (IUSE) activity to a total of $6.0 million, a decrease of $4.90 million. Funds are being redirected to support additional Research Experiences for Undergraduates awards and NSF's new broadening participation activity, NSF INCLUDES ($2.44 million, new in FY 2016).
- ICER houses most of GEO's support for Integrative Graduate Education and Research Traineeship (IGERT) and NSF Research Traineeship (NRT), which combined total $3.52 million within ICER in FY 2016 (a decrease of $1.10 million). IGERT is being phased out as NRT support ramps up.

Infrastructure

- ICER provides GEO's contribution to the National Nanotechnology Coordinated Infrastructure, totaling $300,000.
- ICER continues to provide $14.0 million in support of operation and maintenance for the Ocean Observatories Initiative (OOI). This temporary support, from FY 2015 - FY 2017, enables the Division of Ocean Sciences (OCE) to maintain a strong research portfolio while the Decadal Survey of Ocean Sciences report is being prepared and recommendations considered. This report is expected to guide GEO's future investment decisions in the ocean sciences.
- Mid-Scale Infrastructure: Support for this new activity will enable GEO to invest in emerging infrastructure beyond the scope of the Major Research Instrumentation (MRI) program, but smaller than what is typically funded through NSF's Major Research Equipment and Facilities Construction (MREFC) Account. GEO funding is $9.31 million in FY 2016.

DIVISION OF OCEAN SCIENCES (OCE) $369,610,000
+$13,660,000 / 3.8%

OCE Funding
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, OCE	**$356.27**	**$355.95**	**$369.61**	**$13.66**	**3.8%**
Research	**158.60**	**169.17**	**184.08**	**14.91**	**8.8%**
CAREER	2.07	1.96	2.06	0.10	5.1%
Centers Funding (total)	8.32	7.66	5.00	-2.66	-34.7%
STC: Coastal Margin Observation and Prediction	3.32	2.66	-	-2.66	-100.0%
STC: Dark Energy Biosphere Investigations	5.00	5.00	5.00	-	-
Education	**5.22**	**4.98**	**2.73**	**-2.25**	**-45.2%**
Infrastructure	**192.45**	**181.80**	**182.80**	**1.00**	**0.6%**
Academic Research Fleet	83.00	85.00	85.00	-	-
International Ocean Discovery Program (IODP)	50.00	48.00	48.00	-	-
Ocean Observatories Initiative (OOI)	49.30	41.00	41.00	-	-
Research Resources	8.29	5.80	5.80	-	-
Facilities Pre-Construction Planning (total)	1.86	2.00	3.00	1.00	50.0%
Regional Class Research Vessels (RCRV)	1.86	2.00	3.00	1.00	50.0%

Totals may not add due to rounding.

Research, education, and infrastructure funded by OCE address the central role of the oceans in a changing Earth and as a national strategic resource, as recognized in the President's 2010 Executive Order establishing a National Ocean Policy (NOP) and creating a National Ocean Council (NOC) to implement the policy. OCE supports interdisciplinary research to better understand changing ocean circulation and other physical parameters, biodiversity and the dynamics of marine organisms and ecosystems, and changing ocean chemistry as exemplified by ocean acidification. OCE also supports research on the geology of the ocean margins and sub-seafloor to investigate past conditions, stability of methane hydrates, natural hazards associated with earthquakes and volcanic eruptions, and microbial life deep below the seafloor. Ocean education emphasizes undergraduate REU programs and the interdisciplinary nature of ocean sciences. Since ocean science requires access to the sea, OCE supports research vessels, deep submergence capability including submersibles and autonomous vehicles, and technologically advanced sensors and instrumentation.

In FY 2016, research emphases in OCE will continue to be guided by "*Science for an Ocean Nation: Update of the Ocean Research Priorities Plan*," which was published by the NSTC Subcommittee on Ocean Science and Technology in 2013. This report identifies national research priorities in key areas of interaction between society and the ocean. These priorities include improved understanding of marine ecosystems, marine biodiversity, the impact of increased atmospheric carbon dioxide on ocean acidification, ocean observing, changing conditions in the Arctic, hazards and extreme events, and the enhancement of infrastructure to support ocean and coastal research. Beginning in FY 2014, The National Research Council's Ocean Studies Board began the first Decadal Survey of Ocean Sciences at the request of NSF. The survey objectives are to review the current state of knowledge, identify compelling scientific questions for the next decade, analyze infrastructure needed to address these

questions versus the current NSF portfolio, and identify opportunities to maximize the value of NSF investments. The report is expected to be delivered in early 2015 and will provide valuable community input as the ocean sciences portfolio of research and infrastructure is shaped to maximize scientific return in the coming years.

In general, 27 percent of the OCE portfolio is available for new research grants. The remaining 73 percent supports continuing grants made in previous years and research infrastructure.

FY 2016 Summary

All funding decreases/increases represent change over the FY 2015 Estimate.

Research

- OCE's research budget will increase by $14.91 million, largely through temporary support of OOI operations and maintenance from ICER. The additional funds will go largely towards bolstering ocean science disciplinary and interdisciplinary research programs, which had been reduced in recent years.
- In FY 2016, OCE will maintain support for the Long-Term Ecological Research (LTER) program at a level of $4.75 million.
- OCE will support NSF's INFEWS activity at a level of $1.0 million, new in 2016.
- A new NSF-wide thrust on Risk and Resilience research will be supported by OCE at $7.25 million through GEO's PREEVENTS activity.

Education

- OCE will increase support for REU programs to $2.20 million, an increase of $200,000.
- OCE is ending the postdoctoral fellowship program in FY 2016, as the activity was not attracting the diverse pool of applicants initially envisioned (-$1.50 million).
- Other disciplinary ocean science education efforts will be reduced by $1.0 million, to a total of $500,000 in FY 2016.

Infrastructure

- OCE will increase investment in planning and design for fleet renewal with Regional Class Research Vessels (RCRVs) as a candidate MREFC project by $1.0 million, to a total of $3.0 million.
- Funding for operations and maintenance of the Ocean Observatories Initiative (OOI) will be at $41.0 million in FY 2016. These funds will be supplemented by $14.0 million from ICER, bringing the total operations and maintenance for OOI to $55.0 million, maintaining level support for the program.
- Funding is requested for continued support for operations of the drilling vessel, *JOIDES Resolution (JR)*, as part of the U.S. contribution to the International Ocean Discovery Program (IODP). The FY 2016 request of $48.0 million maintains level funding.
- Funding for operation of the Academic Research Fleet is maintained at $85.0 million.

DIVISION OF POLAR PROGRAMS (PLR) $449,510,000
+$13,160,000 / 3.0%

PLR Funding
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, PLR	**$452.86**	**$436.35**	**$449.51**	**$13.16**	**3.0%**
Research	**129.57**	**125.39**	**130.95**	**5.56**	**4.4%**
CAREER	1.01	1.57	1.65	0.08	5.1%
Centers Funding (total)	2.68	-	-	-	N/A
STC: Center for Remote Sensing of Ice Sheets	2.68	-	-	-	N/A
Education	**2.77**	**3.80**	**2.71**	**-1.09**	**-28.7%**
Infrastructure	**320.52**	**307.16**	**315.85**	**8.69**	**2.8%**
Arctic Research Support and Logistics	44.08	38.64	40.27	1.63	4.2%
IceCube Neutrino Observatory (IceCube)	3.45	3.45	3.45	-	-
U.S. Antarctic Facilities and Logistics	196.99	189.31	195.11	5.80	3.1%
U.S. Antarctic Logistical Support (USALS)	68.94	67.52	67.52	-	-
Polar Environment, Health and Safety (PEHS)	7.07	6.24	6.50	0.26	4.2%
Facilities Pre-Construction Planning (total)	-	2.00	3.00	1.00	50.0%
Antarctic Infrastructure Modernization for Science (AIMS)	-	2.00	3.00	1.00	50.0%

Totals may not add due to rounding.

The Division of Polar Programs (PLR) is the primary U.S. supporter of, and has NSF interagency leadership responsibilities for, fundamental research in the polar regions. Arctic Sciences supports research in social, earth systems, and a broad range of natural sciences; its Research Support & Logistics program responds to research by assisting researchers with access to the Arctic and the planning and sharing of results with local Arctic communities. Antarctic Sciences funds research in a broad range of areas for which access to Antarctica and/or the Southern Ocean is essential to advancing the scientific frontiers. Antarctic Infrastructure & Logistics enables research in Antarctica on behalf of the U.S. government through a network of stations, labs, equipment, and logistical resources. The Environment, Health, and Safety section provides oversight for the environmental, health, and safety aspects of research and operations conducted in polar regions.

PLR's FY 2016 Request reflects three key priorities: (1) maintaining strong disciplinary programs that provide a basis for investments in cross-disciplinary science programs; (2) focusing basic research on cross-foundation (e.g., INFEWS) and interagency priorities; and (3) supporting and improving the efficiency of critical facilities that enable research in both polar regions. For Antarctica, the primary objective is to continue progress on a multi-year commitment toward more efficient and cost-effective science support as recommended by the U.S. Antarctic Program (USAP) Blue Ribbon Panel (BRP) report, *More and Better Science in Antarctica through Increased Logistical Effectiveness.*[1] NSF issued a formal response to this report in March 2013.[2] Emphases include safety and health improvements, investments with positive net present value, and facilities renewal at McMurdo and Palmer stations. Additionally, the Antarctic Sciences community is planning for the more effective observational

[1] www.nsf.gov/od/opp/usap_special_review/usap_brp/rpt/index.jsp
[2] www.nsf.gov/news/news_summ.jsp?cntn_id=127345&org=NSF&from=news

approaches that were outlined in the 2011 National Research Council report, *Future Science Opportunities in Antarctica and the Southern Ocean*,[3] and endorsed by the BRP. For the Arctic, shared cross-directorate basic research objectives, the Interagency Arctic Research Policy Committee's (IARPC) *Arctic Research Plan: FY 2013-2017*,[4] and the *National Ocean Policy Implementation Strategy*[5] inform science investment priorities.

As with most GEO divisions, PLR funds both research and the necessary research support in the form of logistics and infrastructure. The research budget is approximately 30 percent of the total division budget. Of this amount for research, 50 percent is available for new grants each year. The supporting logistics and infrastructure budget is 70 percent of the overall budget.

FY 2016 Summary

All funding decreases/increases represent change over the FY 2015 Estimate.

Research

- Funding for research increases by $5.56 million. There is a $5.50 million reduction in SEES investments, to a total of $3.0 million, as focus areas related to earth systems modeling and Arctic sustainability end. Approximately $4.11 million is redirected toward observation and modeling to advance knowledge about the role of polar oceans in carbon uptake from the atmosphere and the effects of ocean acidification on polar ecosystems. The remaining $1.39 million, together with an increase of $6.01 million, funds basic research supporting national research objectives and fundamental discovery.
- CAREER funding increases by $80,000, to a total of $1.65 million, to encourage participation of early career scientists in research in the polar regions.
- An investment of $1.0 million in the new cross-directorate INFEWS activity will fund research for understanding the mechanisms that enable sustainability and resiliency of global water, food, and energy resources.
- An investment of $2.75 million will fund polar research efforts contributing to the cross-directorate Risk and Resilience emphasis area through the PREEVENTS program.

Education

- In FY 2016, PLR supports IGERT continuing grants at $360,000 and NRT at $550,000.

Infrastructure

- Arctic Research Support & Logistics: This program provides support for Arctic researchers, including airplanes, helicopters, access to icebreakers, and field camps for approximately 150 projects in remote sites in Alaska, Canada, Arctic Scandinavia, Russia, and the Arctic Ocean. Summit Station on the Greenland ice cap operates as a year-round international site for a variety of atmospheric and geophysical measurements. An increase of $1.63 million, to a total of $40.27 million, enables increased use of marine platforms, such as the newly available *Sikuliaq*, for oceanographic research.
- IceCube Neutrino Observatory: PLR continues to match the MPS contribution of $3.45 million for operation and maintenance of the Observatory.

[3] www.nap.edu/catalog.php?record_id=13169
[4] www.nsf.gov/od/opp/arctic/iarpc/arc_res_plan_index.jsp
[5] www.whitehouse.gov/administration/eop/oceans/implementationplan

  - U.S. Antarctic Facilities & Logistics: Funding provides all necessary infrastructure, instrumentation, and logistics for scientists from all disciplines performing research in Antarctica. This support includes forward staging facilities in New Zealand and South America; operation of three year-round stations in Antarctica; Department of Defense fixed-wing aircraft, contracted rotary- and fixed-wing aircraft; two leased research vessels; and icebreaking services from the U.S. Coast Guard in support of annual resupply efforts. An additional $5.80 million, to a total of $195.11 million, supports increased science demands and mandatory military pay raises.
  - The FY 2016 Budget Request for U.S. Antarctic Facilities & Logistics also focuses on continuing progress on Antarctic infrastructure investments recommended by the BRP, such as continued investment in lifecycle replacement of outdated and obsolete equipment, and investment in IT systems, including communications, software, and network upgrades to provide continued connectivity for science and operational needs. Total funding is $18.50 million.
  - An additional $1.0 million, to a total of $3.0 million, for the Antarctic Infrastructure Modernization for Science (AIMS) project to continue the Preliminary Design Review for, among other things, replacing the Palmer Station pier for long-term access to unique research and redeveloping McMurdo Station to be a more efficient and effective facility for supporting Antarctic science. This comprehensive redevelopment of McMurdo involves replacement and reconfiguration of core science, operations, and logistics support facilities. AIMS also includes key area infrastructure upgrades for communications, runway and ship support.
- Polar Environment, Safety and Health: Funding is provided for implementation of both environmental protection and environmental stewardship to minimize the environmental impact of PLR-supported activities in polar regions, as well as programs to ensure the safety and health of participants in Antarctica, and certain Arctic operating locations. An increase of $260,000 permits review of management plans for specially managed or protected areas for which the United States has primary responsibility.

DIRECTORATE FOR MATHEMATICAL AND PHYSICAL SCIENCES (MPS)

$1,366,230,000
+$29,510,000 / 2.2%

MPS Funding
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Astronomical Sciences (AST)	$238.36	$244.16	$246.55	$2.39	1.0%
Chemistry (CHE)	235.18	243.85	251.20	7.35	3.0%
Materials Research (DMR)	267.09	306.99	315.80	8.81	2.9%
Mathematical Sciences (DMS)	224.97	231.73	235.47	3.74	1.6%
Physics (PHY)	267.09	274.99	277.37	2.38	0.9%
Office of Multidisciplinary Activites (OMA)	35.17	35.00	39.84	4.84	13.8%
Total, MPS	**$1,267.86**	**$1,336.72**	**$1,366.23**	**$29.51**	**2.2%**

Totals may not add due to rounding.

About MPS

MPS serves the Nation by supporting fundamental research at the forefront of mathematical and physical sciences. These discoveries are the wellspring of knowledge and innovations that enrich the lives of our citizens. The FY 2016 Request for MPS supports a robust collection of disciplinary and multidisciplinary research programs that foster discovery and develop the technical workforce of the future. Research programs in MPS provide the foundation of basic research in astronomical sciences (AST), chemistry (CHE), materials research (DMR), mathematical sciences (DMS), and physics (PHY) that transforms the frontiers of science.

The portfolio of programs in MPS spans the range from individual investigator awards to large facilities. The majority of awards go to individual investigators and small teams, but centers, institutes, and multi-user facilities are all crucial for MPS-funded science. The MPS mid-scale research infrastructure program, begun over the last few years to meet a critical research need, has received a strong response from the community, and this Request continues to sustain that effort. MPS is also growing research in optics and photonics, one of the promising areas with well-articulated and exciting possibilities.

Programs in the MPS divisions respond to special intellectual opportunities and reflect careful choices about directions that provide the greatest return on the research investment. Discussion with the MPS Advisory Committee (MPSAC) is one means of assessing these opportunities, and three recent reports to the MPSAC have informed plans for research in optics and photonics, for research in food, energy, and water, and for materials research instrumentation. The creation of mid-scale materials innovations platforms and participation in the new multi-directorate program on Innovation at the Nexus of Food, Energy, and Water Systems (INFEWS) follow in part from those reports. The emerging area of Risk and Resilience is also part of the directorate's plan, with MPS participating in aspects such as space weather and modeling of complex systems.

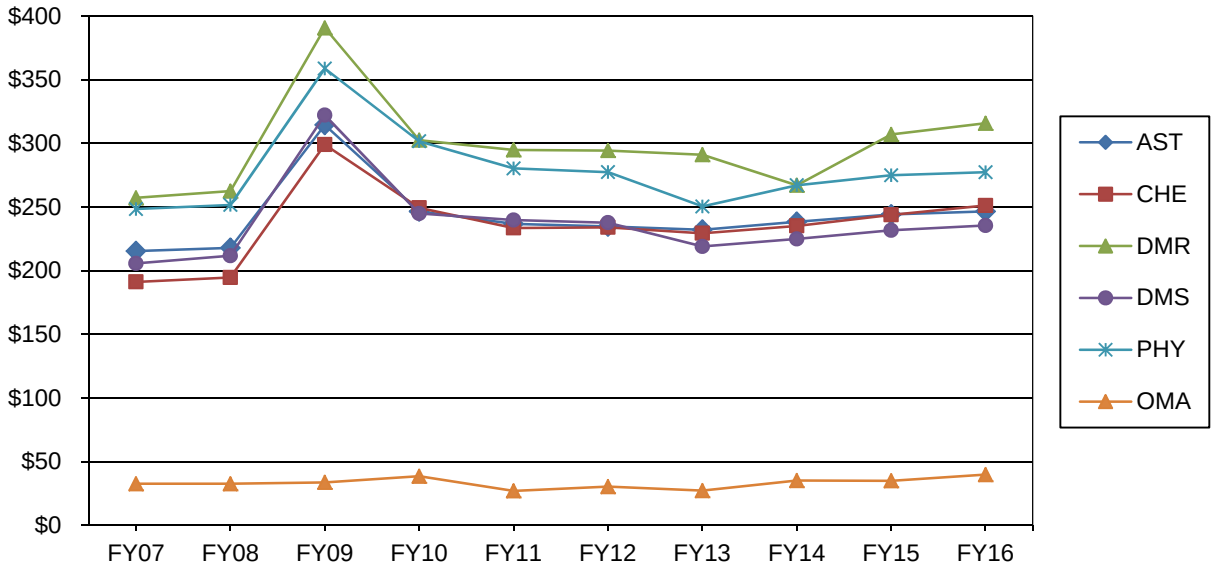
Facilities are an integral part of MPS and enable unique science that is impossible without the special resources of a shared, multi-user environment. Some of these facilities are observatories for photons, neutrinos, or gravitational waves. Others provide unique resources such as the largest controlled magnetic fields in the world or beams of rare ions. Stewardship of the MPS facilities portfolio and the

balance among the different awards programs are critical issues that have engendered extensive community consultation. MPS continues assessing the future of different facilities and fostering partnerships for those facilities.

MPS continues to participate in Foundation-wide and multi-directorate activities. The MPS program in optics and photonics is a partnership with the Directorates for Engineering (ENG) and Computer and Information Science and Engineering (CISE). MPS also partners with them on Enhancing Access to the Radio Spectrum (EARS). Investments continue in cross-Foundation priorities such as Research at the Interface between Biological and Mathematical and Physical Sciences (BioMaPS), which includes research in Understanding the Brain (UtB); Cyber-Enabled Materials, Manufacturing, and Smart Systems (CEMMSS), which includes both Advanced Manufacturing and Designing Materials to Revolutionize and Engineer the Future (DMREF); Cyberinfrastructure Framework for 21st Century Science, Engineering, and Education (CIF21); Secure and Trustworthy Cyberspace (SaTC); and Innovation Corps (I-Corps™). As mentioned above, MPS joins other NSF directorates in initiating INFEWS in FY 2016. Core research funds also contribute to research in clean energy technology and support the program of Research Experiences for Undergraduates (REU). The Sustainable Chemistry, Engineering, and Materials (SusChEM) program is also part of this Request and will continue to evolve even as the NSF program in Science, Engineering, and Education for Sustainability (SEES) ramps-down over the next few years.

MPS provides about 47 percent of the federal funding for basic research at U.S. academic institutions in the mathematical and physical science disciplines.

MPS Subactivity Funding
(Dollars in Millions)



FY 2009 funding reflects both the FY 2009 omnibus appropriation and funding provided through the American Recovery and Reinvestment Act of 2009 (P.L. 111-5).

FY 2016 Summary by Division

- AST's FY 2016 Request will support individual investigator awards and astronomical observatories, as well as investment in the NSF priority areas of EARS and CIF21 and the major MPS priority area of mid-scale research infrastructure. Funding for individual investigator research is balanced against funding for facilities. Among facilities, support for the Daniel K. Inouye Solar Telescope (DKIST) increases.

- CHE's FY 2016 Request provides enhanced support for core programs and features a focus on INFEWS as a major research driver. CHE will continue commitment to research in clean energy technologies, advanced manufacturing, CIF21, and DMREF. CHE also strongly supports research at the interfaces with biology and materials research, within both experimental and theoretical/computational frameworks, including the major cross-Foundation effort, UtB.

- DMR's FY 2016 Request includes plans to increase its portfolio of individual investigator awards, specifically in NSF focus areas where advanced materials are essential such as CEMMSS through DMREF, BioMaPS, and UtB. DMR will continue its Materials Innovation Platforms (MIP) program started in FY 2015 and will continue a strong commitment to research in the area of clean energy technologies.

- DMS's FY 2016 Request is focused on enhancing support for frontier research, training a diverse group of researchers in mathematical and statistical sciences with computational skills, investing in mathematical sciences institutes, and providing support through efficient mechanisms to foster multidisciplinary research activities in, but not limited to, CIF21, SEES, BioMaPS, CEMMSS, SaTC and UtB.

- PHY's FY 2016 Request includes continued support for individual investigator awards, particularly those in NSF-wide priority areas such as CIF21, BioMaPS, and UtB. PHY also requests increased funding for investigators using its major facilities, and for operations and maintenance of these facilities. In FY 2016, PHY will maintain its program in accelerator science and will also increase its commitment to the MPS priority area of mid-scale research infrastructure.

- OMA will continue its role of supporting multidisciplinary research and activities in education and broadening participation. OMA will emphasize research relevant to NSF priorities such as SEES, CIF21, BioMaPS, UtB, and CEMMSS. OMA will coordinate MPS activities related to I-Corps™, NSF Research Traineeship (NRT), and INSPIRE. In addition, OMA will support responsible decisions regarding portfolio composition, including studies of possible environmental issues, stewardship transition costs, or partnership start-up costs; in FY 2016, the focus will be on implementing recommendations pursuant to the facilities portfolio analysis.

Major Investments

MPS Major Investments
(Dollars in Millions)

Area of Investment	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
BioMaPS	$18.85	$11.96	$13.00	$1.04	8.7%
CAREER	77.22	66.56	69.89	3.33	5.0%
CEMMSS	68.10	40.66	49.84	9.18	22.6%
Advanced Manufacturing	*64.86*	*40.66*	*49.84*	*9.18*	*22.6%*
Clean Energy Technology	135.50	144.13	143.34	-0.79	-0.5%
CIF21	32.34	11.50	16.15	4.65	40.4%
I-Corps™	1.42	1.00	1.70	0.70	70.0%
INFEWS	-	-	8.90	8.90	N/A
INSPIRE	1.33	3.00	3.00	-	-
NRT[1]	4.64	4.51	4.47	-0.04	-0.9%
Risk and Resilience	-	-	1.00	1.00	N/A
SEES	25.36	22.50	16.00	-6.50	-28.9%
SaTC	2.00	0.50	1.50	1.00	200.0%
Understanding the Brain	13.08	14.18	18.70	4.52	31.9%

Major investments may have funding overlap and thus should not be summed.

[1] Outyear commitments for Integrative Graduate Education and Research Traineeship (IGERT) are included in the NRT line and are $4.64 million in FY 2014, $2.0 million in FY 2015, and $820,000 in FY 2016.

- BioMaPS is increased by $1.04 million (to a total of $13.0 million). This interface continues to be an exciting growth area, the focus of which is the partnership with BIO and ENG that will emphasize research towards Understanding the Brain (UtB) and other emerging areas of multidisciplinary science.

- CAREER remains a top priority for MPS, with an increase of $3.33 million (to a total of $69.89 million), ensuring that top young scientists in all of the MPS disciplines are funded at an appropriate level. The CAREER program is an important element in the growth and maturity of young scientists, and MPS commensurately directs investments into the CAREER program.

- MPS's contribution to Advanced Manufacturing, part of Cyber-Enabled Materials Manufacturing and Smart Systems (CEMMSS), is made through its DMREF program. This is a response to the Administration's Materials Genome Initiative. The DMREF program has received very strong interest from MPS communities, and with an increase of $9.18 million (to a total of $49.84 million) in FY 2016, MPS will be able to fund additional highly meritorious proposals to advance materials discovery by closely linking theory, modeling, and experimentation, an approach critical to solving related research challenges in areas such as optics and photonics, clean energy, and the brain.

- Clean energy technology research remains strong in MPS core programs with FY 2016 support of $143.34 million.

- MPS's Computational and Data-Enabled Science and Engineering (CDS&E) program has been successful because of its effective interdisciplinary and interdirectorate management process, a process that assures the awareness of submitted CDS&E proposals among interested and participating programs in MPS, ENG, and CISE. MPS increases this portion of the CIF21 initiative by $4.65 million to a total of $16.15 million.

- MPS nearly doubles its investment in the NSF I-Corps™ program (up $700,000 to a total of $1.70 million) in FY 2016, primarily to fund I-Corps™ teams. In FY 2013 through FY 2015, the MPS investment in I-Corps™ supported a combination of Teams and Nodes. Beginning in FY 2016, the MPS investment in I-Corps™ will be directed exclusively to support Team awards. The increase will permit support for about 10 additional Teams. Investments in I-Corps™ are directed to an assessment of the commercial viability of the scientific discoveries in MPS disciplines through the individual investigator award program.

- In FY 2016, MPS joins other NSF directorates to initiate Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS), with an initial investment of $8.90 million. MPS divisions will publicize relevant funding opportunities via Dear Colleague Letters (DCLs), organize and conduct workshops in FY 2015 on selected INFEWS topics, and use an incubator program as one mechanism to fund research to address challenges related to INFEWS. These activities provide the potential for cross directorate cooperation and further building of research communities to address sustainability issues.

- MPS maintains its $3.0 million commitment to INSPIRE.

- MPS will invest $4.47 million in FY 2016 for NRT and finish the out-year commitments for Integrative Graduate Education & Research Traineeship (IGERT). This total includes both an increase for the NRT program (+$1.14 million to a total of $3.65 million) as well as the final increment on the sunsetting IGERT awards (-$1.18 million to a total of $820,000).

- MPS joins GEO, ENG, and SBE in funding programs under the Risk and Resilience portfolio. Contributions in FY 2016 will start at $1.0 million, split among AST, CHE, and DMS. Scientific research supported by MPS will improve predictive and risk-assessment capabilities, increasing resilience to reduce the impact on civilization of extreme events. Work on fundamental scientific issues, such as understanding the dynamic processes that produce extreme events, will advance knowledge and help to create tools for increased resilience of societal infrastructure to natural and man-made hazards.

- SEES investments drop $6.50 million (to a total of $16.0 million) as this initiative continues to sunset. Much of the remaining funding will focus on sustainable chemistry (SusChEM) research.

- MPS's contribution to SaTC, all within DMS, increases $1.0 million (to a total of $1.50 million). Questions surrounding securing information networks against hostile intrusion and ensuring individual privacy in anonymized data sets present crucial challenges for society. Research supported by DMS through SaTC will provide a fresh look at such current cybersecurity challenges from the viewpoint of the mathematical sciences.

- UtB funding in MPS is increased $4.52 million (to a total of $18.70 million) as this important interdisciplinary area ramps up within NSF. In FY 2016, the MPS investment in UtB will focus on advancing the understanding of model animal and healthy human brains, including an emphasis on computational modeling and simulation and the exploration of inter-neuronal communications.

MPS Funding for Centers Programs and Facilities

MPS Funding for Centers Programs
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, Centers Programs	**$68.89**	**$93.77**	**$92.79**	**-$0.98**	**-1.0%**
Centers for Analysis & Synthesis (DMS)	0.20	0.10	0.20	0.10	100.0%
Centers for Chemical Innovation (CHE)	35.49	30.51	32.00	1.49	4.9%
Materials Centers (DMR)[1]	24.82	56.00	56.00	-	-
Nanoscale Science & Engineering Centers (CHE, DMR, PHY)	1.19	0.52	0.50	-0.02	-3.8%
Science & Technology Centers (DMR)	7.19	6.64	4.09	-2.55	-38.4%

Totals may not add due to rounding.

[1] Due to end-of-fiscal year deadlines, $29.81 million in funding for new Materials Center awards was carried over from FY 2014 and obligated in early FY 2015.

For detailed information on individual centers, please see the NSF-Wide Investments chapter.

- Centers for Analysis and Synthesis (+$100,000 to a total of $200,000). This increase returns support for the BIO-managed National Institute for Mathematical and Biological Synthesis to its historic commitment level.

- Centers for Chemical Innovation (+$1.49 million to a total of $32.0 million): In FY 2016 up to nine Phase II CCIs will be funded at $32.0 million ($1.49 million below the FY 2015 Estimate). Total funding required to support nine CCIs in FY 2016 is $36.0 million. Of this total, $32.0 million is provided in this Request. The remaining $4.0 million will be provided via co-funding and forward funding from previous years. The last set of Phase I Centers will compete for Phase II awards in FY 2015 with no new Phase I Centers supported until the program is evaluated and redesigned in future years.

- The Materials Research Science and Engineering Centers (MRSECs) advance materials research through collaborations of groups of principal investigators, provide students with a rich, interdisciplinary education, and address fundamental research problems of intellectual and strategic importance that will advance U.S. competitiveness. MRSEC competitions are usually held triennially, the last in FY 2014. In FY 2016, 21 new and continuing awards are expected to be supported.

- MPS divisions continue to support (-$20,000 to a total of $500,000) two nanoscale-related center awards as support for NSECs agency-wide winds down as planned.

- Science and Technology Centers (STCs) (-$2.55 million to a total of $4.09 million): Funding for the STCs reflects the planned sunset of the Center for Layered Polymeric Systems in FY 2015. In FY 2016, support for the Center on Integrated Quantum Materials increases as planned (+$110,000 for a total $4.09 million).

MPS Funding for Facilities

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, Facilities	**$281.13**	**$271.38**	**$281.78**	**$10.40**	**3.8%**
Arecibo	4.50	4.00	4.10	0.10	2.5%
Atacama Large Millimeter/Submil. Array (ALMA)	34.27	40.17	40.35	0.18	0.4%
Cornell High Energy Synchrotron Source (CHESS)	10.00	10.00	10.00	-	-
Daniel K. Inouye Solar Telescope (DKIST)	2.00	7.00	11.00	4.00	57.1%
Gemini Observatory	19.58	20.61	19.77	-0.84	-4.1%
IceCube Neutrino Observatory (IceCube)	3.45	3.45	3.45	-	-
Large Hadron Collider (LHC)	17.37	18.00	18.00	-	-
Large Synoptic Survey Telescope (LSST)	6.59	-	-	-	N/A
Laser Interferometer Gravitational-wave Observatory (LIGO)	36.43	39.43	39.43	-	-
National High-Magnetic Field Laboratory (NHMFL)	42.26	24.04	34.66	10.62	44.2%
National Nanotechnology Coordinated Infrastructure (NNCI)	-	2.88	2.88	-	-
National Nanotechnology Infrastructure Network (NNIN)	2.88	-	-	-	N/A
National Optical Astronomy Observatory (NOAO)	25.50	25.50	21.75	-3.75	-14.7%
National Radio Astronomy Observatory (NRAO)	43.14	43.14	41.73	-1.41	-3.3%
National Solar Observatory (NSO)[1]	8.00	8.00	9.50	1.50	18.8%
National Superconducting Cyclotron Laboratory (NSCL)	22.50	22.50	22.50	-	-
Center for High Resolution Neutron Scattering (CHRNS)	2.66	2.66	2.66	-	-

[1] The totals presented in FY 2015 and FY 2016 do not include $5.0 millon and $9.0 million, respectively, for operations and maintenance support for the DKIST facility construction project. That funding is captured within the total presented on the DKIST line above.

For detailed information on individual facilities, please see the Facilities chapter.

MPS sustains operations and maintenance budget levels for most of its large user facilities. Exceptions to this include:

- Daniel K. Inouye Solar Telescope (DKIST): Funding (+$4.0 million to a total of $11.0 million) represents the second year of the ramp to full DKIST operations, expected in FY 2019. The total is comprised of $9.0 million for basic DKIST operations support provided through the National Solar Observatory and $2.0 million in a separate award as part of the cultural mitigation process for DKIST construction. (See the MREFC chapter for more on DKIST.)

- National High-Magnetic Field Laboratory (NHMFL): Funds (+$10.62 million to a total of $34.66 million) are requested to continue transformational research using high magnetic fields. In FY 2014, NHMFL was forward funded by $9.63 million, reducing the amount needed in FY 2015. FY 2016 funding returns to the level in the current cooperative agreement.

- National Nanotechnology Coordinated Infrastructure (NNCI): Funds (a total of $2.88 million) are requested for MPS's contribution to NNCI, the successor to the National Nanotechnology Infrastructure Network (NNIN).

- National Optical Astronomy Observatory (NOAO): In FY 2016, this observatory will execute a transformation to a new operations model emphasizing data science, with a reduction in base funding (-$3.75 million to a total of $21.75 million) associated with a reduction in telescope operations. This includes initiation of a joint NSF-NASA Exoplanet Research Program (NN-EXPLORE) on the 3.5m WIYN telescope and discussions regarding potential partnerships for the Mayall telescope.

- National Radio Astronomy Observatory (NRAO): Funding for domestic NRAO (-$1.41 million to a total of $41.73 million) returns to the level outlined in the baseline plan.

- National Solar Observatory (NSO): This increase (+$1.50 million to a total of $9.50 million) includes a decrement of $1.0 million to basic NSO operations (for a total of $7.0 million) and a one-time increment of $2.50 million for refurbishment of the Global Oscillation Network Group (GONG) telescopes in order to facilitate robust space-weather predictions. The total presented does not include $9.0 million in support of the ramp to operations for DKIST; that funding is captured within the DKIST line in the table above.

Summary and Funding Profile

MPS supports core research and education as well as research infrastructure. MPS will invest heavily in areas such as INFEWS, Advanced Manufacturing, CIF21, and UtB, while increasing its investment in core research areas. Mid-scale research infrastructure in several MPS divisions will continue to increase in response to community needs in these areas.

In FY 2016, the number of research grant proposals to MPS is expected to be similar to FY 2015, with research grant award funding rates expected to rise slightly as a function of greater availability. Average annual award size and duration are not expected to materially fluctuate in FY 2014 through FY 2016.

In FY 2016, MPS will invest $92.79 million for Centers, accounting for 6.8 percent of the MPS budget. This total is very similar to the FY 2015 Estimate. Centers are an important modality for MPS sciences as research in many MPS-supported disciplines, especially CHE and DMR, has evolved to be more collaborative and interdisciplinary.

Operations and maintenance funding for MPS-supported user facilities comprises 20.6 percent of MPS's FY 2016 Request. MPS has sustained operations budgets for most facilities to maintain current operational capacity. Several have budgets decreased as a function of reductions in scope, while others have budgets increased as new facility capabilities have come online.

MPS Funding Profile

	FY 2014 Actual Estimate	FY 2015 Estimate	FY 2016 Estimate
Statistics for Competitive Awards:			
Number of Proposals	8,856	8,900	9,000
Number of New Awards	2,344	2,500	2,500
Funding Rate	26%	28%	28%
Statistics for Research Grants:			
Number of Research Grant Proposals	7,732	7,700	7,800
Number of Research Grants	1,854	1,900	2,000
Funding Rate	24%	25%	26%
Median Annualized Award Size	$120,000	$120,000	$120,000
Average Annualized Award Size	$140,683	$140,000	$140,000
Average Award Duration, in years	3.2	3.2	3.2

Program Monitoring and Evaluation

External Program Evaluations and Studies:

- The MPS Advisory Committee (MPSAC) released three Subcommittee reports in 2014:
  - *Food, Energy, and Water: Transformative Research Opportunities in the Mathematical and Physical Sciences* informs the Directorate's future plans to invest in sustainability science.
  - *Optics and Photonics: Transformative Research Opportunities in the Mathematical and Physical Sciences* informs future plans to invest to advance optics and photonics science.
  - *Closing the Loop: Report of the MPSAC Subcommittee on Materials Instrumentation* informs future plans to invest to support materials synthesis and discovery.[1]
- The Astronomy and Astrophysics Advisory Committee (AAAC) completed their annual report on interagency activities by the Department of Energy (DOE), NASA, and NSF in March 2014. The next annual report is expected in March 2015.
- The Committee on Astronomy and Astrophysics of the National Academy of Sciences (NAS), National Research Council (NRC), has been commissioned to carry out a study of "A Strategy to Optimize the U.S. Optical/Infrared System in the Era of the Large Synoptic Survey Telescope." A report is expected in Spring 2015.
- AST, together with the NASA Astrophysics Division and the High Energy Physics Branch of the DOE Office of Science, is commissioning a mid-decadal study through the NRC Committee on Astronomy and Astrophysics. The committee is expected to receive a complete charge in FY 2015 and issue a report in FY 2016.
- DMS implemented recommendations of the 2013 report *The Mathematical Sciences in 2025*[2] by the Board on Mathematical Sciences and their Applications of the National Research Council. In response to the report, DMS instituted the Mathematical Sciences Innovation Incubator (MSII) activity.[3]
- NSF and DOE received a report in May 2014 from a subcommittee of the Nuclear Science Advisory Committee (NSAC) that was charged with developing evaluation criteria for a next-generation

[1] www.nsf.gov/mps/advisory/mpsac_other_reports/materials_instrumentation-final_from_subcommittee.pdf
[2] www.nap.edu/catalog/15269/the-mathematical-sciences-in-2025
[3] www.nsf.gov/funding/pgm_summ.jsp?pims_id=505044

detector of neutrino-less nuclear double beta decay.

- NSF and DOE received a report in May 2014 from the High-Energy Physics Advisory Panel (HEPAP) to reform the Particle Physics Project Prioritization Panel (P5) and to develop a strategic plan for particle physics covering the next 10 years. The MPS Advisory Committee formed a subcommittee to provide advice on NSF-specific implementation options for the strategic plan. The subcommittee is expected to issue a report in early 2015.
- NSF and DOE have asked NSAC to develop a long-range strategic plan for nuclear physics covering the next 10 years. A report is expected by mid-2015.

Science and Technology Policy Institute (STPI) Reports:

- STPI completed a pilot study in FY 2014 of the DMS Mathematical Sciences Research Institutes to examine the feasibility of evaluation for institute programs using qualitative methods. The study provided options for further evaluation of program outcomes and recommendations regarding case study logistics, currently under review by DMS.

Workshops and Reports:

- CHE sponsored the U.S. Young Observer (YO) Program for the 2013 and 2015 Congress and General Assembly of the International Union of Pure and Applied Chemistry (IUPAC). Data collection from the YOs on the impact of the experience on their professional careers is continuing. Eleven YOs from the U.S. attended the 2013 event and presented papers at the General Assembly and World Chemistry Congress. The results have been shared with the U.S. National Committee for IUPAC in written and verbal forms via meeting materials.
- CHE sponsored a workshop on Laboratory Safety in March 2012 at the National Academy of Sciences' Beckman Center in Irvine, CA. Workshop outcomes and recommendations were published in the Journal of Chemical Health & Safety, January/February 2013.[4] The final report, *Safe Science: Promoting a Culture of Safety in Academic Chemical Research*, was published in July 2014. [5]
- In concert with the focus on Advanced Manufacturing, CHE co-sponsored with BIO the workshop, "Industrialization of Biology: A Roadmap to Accelerate Advanced Manufacturing of Chemicals" in 2014. A final report is forthcoming.
- In the context of Big Data, CHE sponsored the workshop, "Data-Driven Organic Chemistry" in September 2014 and will sponsor "Mass Spectrometry Big Data to Knowledge" in May 2015. The latter workshop is co-sponsored by DMS and SBE internally, NIH and NIST externally.
- CHE and the NASA Astrobiology Program co-sponsored an international workshop on "Alternative Chemistries of Life" in 2013. The highly interdisciplinary nature of the workshop produced interesting suggestions for future areas/lines of research. The final report was published in 2014.[6]
- DMR sponsored a Partnerships for Research and Education in Materials (PREM) Workshop as part of the MRS Fall Meeting in Boston in November 2014. This workshop brought together past and present PREM students for professional and career development activities.
- In May 2014, DMR sponsored a workshop on "Combinatorial Approaches to Functional Materials," which focused on challenges and opportunities to maximize the impact of theoretical and experimental combinatorial materials science to the Materials Genome Initiative. This workshop identified grand challenges for combinatorial materials research, assessing current practice to determine the approach, costs, risks, timescales, and payoffs in going forward.
- DMR and the DOE Office of Basic Energy Sciences (BES) co-sponsored a joint DOE/NSF Materials Genome Initiative (MGI) Principal Investigators' Meeting on January 12-13, 2015. This meeting brought together principal investigators from NSF's DMREF program and the DOE's Predictive Theory and Modeling Program.

[4] www.dx.doi.org/10.1016/j.jchas.2012.10.002
[5] www.nap.edu/catalog.php?record_id=18706
[6] http://chemistry.emory.edu/home/assets/alternativechem.pdf

- The report *Materials Genome Initiative: The Interplay of Experiment, Theory and Computation 2013* was published in the Current Opinion in Solid State and Materials Science in 2014. This was the follow up to the DMR-sponsored "The Materials Genome Initiative and the Synergy Between Computation and Experiment" in December 2012.
- In response to the 2013 report of the project "Investing in the Next Generation through Innovative and Outstanding Strategies for Mathematics and Statistics" (INGenIOuS),[7] DMS designed and implemented a new program in FY 2015, "Enriched Doctoral Training in the Mathematical Sciences" (EDT).[8] This program, through research training, prepares Ph.D. students to recognize, and find solutions to, mathematical challenges arising in other fields and in areas outside today's academic setting.
- To spotlight opportunities for mathematical sciences research in connection with the DMREF program, DMS is sponsoring a Symposium on Mathematical and Computational Aspects of Materials Science in connection with the Society for Industrial and Applied Mathematics conference on Computational Science & Engineering in March 2015.[9]

Committees of Visitors (COV):

- In FY 2013, COVs reviewed CHE and DMS. The COV reports and the divisions' responses can be found on the MPS AC website. The divisions are responding to and implementing recommendations from these reviews.
- In FY 2015, COVs will review AST, DMR, and PHY.
- In FY 2016, COVs will review DMS.

The Performance chapter provides details regarding the periodic reviews of programs and portfolios of programs by external Committees of Visitors and directorate Advisory Committees. Please see this chapter for additional information.

Number of People Involved in MPS Activities

	FY 2014 Actual Estimate	FY 2015 Estimate	FY 2016 Estimate
Senior Researchers	7,813	8,200	8,400
Other Professionals	2,995	3,200	3,200
Postdoctorates	1,983	2,000	2,100
Graduate Students	8,419	8,900	9,000
Undergraduate Students	5,307	5,600	5,700
Total Number of People	**26,517**	**27,900**	**28,400**

[7] www.maa.org/programs/faculty-and-departments/ingenious
[8] www.nsf.gov/funding/pgm_summ.jsp?pims_id=505083
[9] www.siam.org/meetings/cse15/symposium.php

DIVISION OF ASTRONOMICAL SCIENCES (AST) $246,550,000
+$2,390,000 / 1.0%

AST Funding
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, AST	**$238.36**	**$244.16**	**$246.55**	**$2.39**	**1.0%**
Research	**64.04**	**67.08**	**62.72**	**-4.36**	**-6.5%**
CAREER	4.76	4.82	4.72	-0.10	-2.1%
Education	**6.24**	**5.90**	**6.66**	**0.76**	**12.9%**
Infrastructure	**168.08**	**171.18**	**177.17**	**5.99**	**3.5%**
Arecibo Observatory	4.50	4.00	4.10	0.10	2.5%
Atacama Large Millimeter/submm Array (ALMA)	34.27	40.17	40.35	0.18	0.4%
Daniel K. Inouye Solar Telescope (DKIST)	2.00	7.00	11.00	4.00	57.1%
Gemini Observatory	19.58	20.61	19.77	-0.84	-4.1%
Nat'l Optical Astronomy Obs. (NOAO)	25.50	25.50	21.75	-3.75	-14.7%
Nat'l Radio Astronomy Obs. (NRAO)	43.14	43.14	41.73	-1.41	-3.3%
Nat'l Solar Observatory (NSO)[1]	8.00	8.00	9.50	1.50	18.8%
Mid-Scale Innovations Program (MSIP)	14.15	13.00	18.72	5.72	44.0%
Research Resources	10.35	9.76	10.25	0.49	5.0%
Facilities Pre-Construction Planning (total)	6.59	-	-	-	N/A
Large Synoptic Survey Telescope (LSST)	6.59	-	-	-	N/A

Totals may not add due to rounding.

[1] The totals presented in FY 2015 and FY 2016 do not include $5.0 millon and $9.0 million, respectively, for operations and maintenance support for the DKIST facility construction project. That funding is captured within the total presented on the DKIST line above.

AST is the federal steward for ground-based astronomy in the United States, funding research with awards to individual investigators and small research groups, and via cooperative agreements for operation of large telescope facilities. These national and international telescope facilities provide world-leading, one-of-a-kind observational capabilities on a competitive basis to thousands of astronomers per year. These facilities also enable scientific advances by making archived data products available to researchers. Along with funding telescope facilities and research awards, AST supports the development of advanced technologies and instrumentation and manages the electromagnetic spectrum for scientific use by the entire NSF community.

In general, 24 percent of the AST portfolio is available for new research grants and 76 percent is available for continuing grants and cooperative awards.

AST supports research to understand the origins and characteristics of planets, stars, and galaxies, as well as the structure that has evolved in the Universe since its origin more than 13 billion years ago. The results of this research will lead to a better understanding of the cosmos in which we live, of the possibility of life existing on planets circling other stars, and of the nature of the mysterious dark matter and dark energy that comprise more than 95 percent of the mass-energy of the Universe.

Approximately 72 percent of AST's budget supports the forefront instrumentation and facilities needed

for progress at the frontiers of observational astronomy, while the remaining 28 percent supports the research of individual investigators. Through the MREFC account, AST also oversees the construction of the Large Synoptic Survey Telescope (LSST) and the Daniel K. Inouye Solar Telescope (DKIST).

In 2010, the National Research Council conducted its sixth decadal survey in astronomy and astrophysics. In their report, *New Worlds, New Horizons in Astronomy and Astrophysics*,[10] the NRC committee recommended that "NSF-Astronomy should complete its next senior review before the mid-decade independent review that is recommended in this report, so as to determine which, if any, facilities NSF-AST should cease to support in order to release funds for (1) the construction and ongoing operation of new telescopes and instruments and (2) the science analysis needed to capitalize on the results from existing and future facilities." In response to this recommendation, AST conducted a community-based review of its portfolio. The resulting Portfolio Review Committee (PRC) report, *Advancing Astronomy in the Coming Decade: Opportunities and Challenges*,[11] was released in August 2012 and included recommendations about all of the major AST telescope facilities.

In FY 2012 and FY 2013, AST began to engage actively in facility partnership discussions with other federal agencies and with university-based groups. In FY 2014, AST continued those discussions, and NSF brought a general engineering contractor on-board for all its engineering and environmental reviews. In FY 2015, that contractor is producing feasibility reports for divestment alternatives, which will provide the results of baseline structural and environmental surveys of a number of individual telescopes and observatories. Once NSF has identified viable options for divestment, it will embark on formal reviews (in FY 2015 and FY 2016) to evaluate environmental impacts of these options, including partnership opportunities that could have impacts to the environment. Details for individual facilities are described in the Facilities chapter of this Budget Request.

FY 2016 Summary

All funding decreases/increases represent change over the FY 2015 Estimate.

Research

- Astronomy and Astrophysics Research Grants program (-$2.74 million to a total of $41.36 million): Following an increase in FY 2015 that was enabled by the conclusion of construction planning and development for LSST, in FY 2016 this program is decreased.
- The Theoretical and Computational Astrophysics Networks program executed in conjunction with NASA is decreased 100 percent (-$1.50 million to zero). A joint program evaluation with NASA will be conducted to determine whether another cycle of this program is instituted in FY 2017.

Education

- Astronomy and Astrophysics Postdoctoral Fellowship program (+$100,000 to a total of $2.40 million): Increased funding enables one additional fellowship award in FY 2016.
- Partnerships in Astronomy and Astrophysics Research and Education (+$1.0 million to a total of $2.0 million): AST enhances its efforts to diversify the astronomical research community by increasing support in this program by 100 percent.

Infrastructure

- Atacama Large Millimeter/Submillimeter Array (+$180,000 to a total of $40.35 million): Funding sustains the transition from construction to full operations. A major operations review will take place

[10] www.nap.edu/catalog.php?record_id=12951
[11] www.nsf.gov/mps/ast/ast_portfolio_review.jsp

in FY 2015 to evaluate future funding requirements.

- Daniel K. Inouye Solar Telescope (+$4.0 million to a total of $11.0 million): Funding represents the second year of the ramp to full DKIST operations, expected in FY 2019. The total is comprised of $9.0 million for basic DKIST operations support provided through the National Solar Observatory and $2.0 million in a separate award as part of the cultural mitigation process for DKIST construction. (See the MREFC chapter for more on DKIST.)
- Gemini (-$840,000 to a total of $19.77 million): Funding represents a flat operations budget ($18.02 million) and a decrease in new instrumentation funding (-$840,000 to $1.75 million) as Gemini transitions to a new partnership model emphasizing in-kind instrumentation contributions.
- National Optical Astronomical Observatory funding (-$3.75 million to a total of $21.75 million): The observatory will transform to a new operations model emphasizing data science, with a reduction in base associated with a reduction in telescope operations. This includes initiation of a joint NSF-NASA Exoplanet Research Program (NN-EXPLORE) on the 3.5m WIYN telescope and discussions regarding potential partnerships for the Mayall telescope.
- National Radio Astronomical Observatory (-$1.41 million to a total of $41.73 million: The funding reduction for domestic, non-ALMA NRAO represents a return to the baseline NRAO plan.
- National Solar Observatory (+$1.50 million to a total of $9.50 million): This increase includes a decrement of $1.0 million to basic NSO operations (for a total of $7.0 million) and a one-time increment of $2.50 million for refurbishment of the Global Oscillation Network Group (GONG) telescopes in order to facilitate robust space-weather predictions. The total presented does not include $9.0 million in support of the ramp to operations for DKIST; that funding is captured within the DKIST line in the table above. For more information, see the Facilities chapter.
- Mid-Scale Innovations Program (MSIP) (+$5.72 million to a total of $18.72 million): A significant funding increase supports the second AST solicitation for MSIP proposals, sustaining experiments, student instrumentation training, and access to non-federal observatories and data sets at funding levels of up to ~$20.0 million for individual projects, a research scale not accessible for normal individual investigator grants.

DIVISION OF CHEMISTRY (CHE)

$251,200,000
+$7,350,000 / 3.0%

CHE Funding
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Percent
Total, CHE	**$235.18**	**$243.85**	**$251.20**	**$7.35**	**3.0%**
Research	**221.11**	**233.30**	**238.00**	**4.70**	**2.0%**
CAREER	25.53	23.57	24.66	1.09	4.6%
Centers Funding (total)	33.89	30.76	32.25	1.49	4.8%
Centers for Chemical Innovation	33.49	30.51	32.00	1.49	4.9%
Nanoscale Science & Engineering Centers	0.40	0.25	0.25	-	-
Education	**7.45**	**6.25**	**6.01**	**-0.24**	**-3.8%**
Infrastructure	**6.62**	**4.30**	**7.19**	**2.89**	**67.2%**
National High Magnetic Field Laboratory (NHMFL)	3.58	-	1.88	1.88	N/A
National Nanotechnology Coordinated Infrastructure (NNCI)	-	0.30	0.30	-	-
National Nanotechnology Infrastructure Network (NNIN)	0.30	-	-	-	N/A
Research Resources	2.74	4.00	5.01	1.01	25.3%

Totals may not add due to rounding.

CHE supports a large and vibrant research community engaged in fundamental research linked to key national priorities. CHE will enable research in sustainability and clean energy, providing new molecules and tools that are essential to our economy and well-being. Through the development of new methodologies in chemical synthesis, CHE is a natural contributor to advancing manufacturing technology. CHE strongly supports research at the interfaces with biology and materials research, within both experimental and theoretical/computational frameworks. CHE's programs invite research in catalysis for energy capture and storage as well as for the formation of new chemical bonds, appreciation of, and insight into, the chemistry of life processes, new nano-structured materials that will revolutionize electronics and photonics, and better awareness of how nano-size aerosols and particles impact our environment. In addition, CHE supports curiosity-driven research that leads to increased understanding of molecules and their chemical transformations, as well as the development of new instrumentation to study and detect molecules.

In general, 59 percent of the CHE portfolio is available for new research grants and 41 percent goes to continuing grants; the Centers for Chemical Innovation program constitutes 43 percent of continuing grant commitments in FY 2016. Almost 85 percent of CHE's budget is used to support individuals and small groups of researchers, while about 15 percent of the budget supports centers and facilities.

FY 2016 Summary

All funding decreases/increases represent change over the FY 2015 Estimate.

Research

- CAREER (+$1.09 million to a total of $24.66 million): CHE continues its commitment to young investigators. This increase will fund two to three additional awards.
- Centers for Chemical Innovation (+$1.49 million to a total of $32.0 million): This increase in FY 2016 is due to forward funding in FY 2014, which allowed lower level in FY 2015. The last set of Phase I Centers will compete for Phase II awards in FY 2015 with no new Phase I Centers supported until the program is evaluated and redesigned in future years.
- Advanced Manufacturing continues to be important, increasing 8.6 percent, with projects supported through unsolicited individual investigator grants and the Centers for Chemical Innovation program (+$1.33 million to a total of $16.74 million).
- SEES (-$3.0 million to a total of $10.0 million): Plans are being developed to mainstream the SusChEM activities into the CHE individual investigator award programs and thematically-related centers in the Centers for Chemical Innovation program. The SEES Postdoctoral Fellows Program is discontinued in FY 2015 and the funds folded into SusChEM activities.
- CHE begins a new investment ($7.20 million) in sustainability through the NSF-wide program, Innovations at the Nexus of Food, Energy, and Water Systems, via joint solicitations, Dear Colleague Letters, and unsolicited proposals through the Environmental Chemical Sciences and Chemical Measurement and Imaging Programs.
- Understanding the Brain (+$260,000 to a total of $3.80 million): CHE continues to grow investments in this cross-Foundation activity.

Education

- CHE maintains a commitment to Research Experiences for Undergraduates at $5.05 million.
- CHE maintains its commitment to diversity through programs such as ADVANCE at $800,000.
- CHE's overall education investments are down (-$240,000 to a total of $6.01 million) mainly due to the discontinuation of the SEES Postdoctoral Fellows Program and the Office of Multidisciplinary Activities assumption of MPS's commitments to the NRT program.

Infrastructure

- National High Magnetic Field Laboratory (+$1.88 million to a total of $1.88 million): CHE funding for NHMFL supports the maintenance and operation of the recently installed 21-Tesla magnet at the Ion Cyclotron Resonance (ICR) facility. NHMFL was forward-funded in FY 2014 to cover the entire FY 2015 increment; FY 2016 funding returns to the level in the current cooperative agreement.
- National Nanotechnology Coordinated Infrastructure (no change at $300,000): Funds are requested for CHE's contribution to NNCI, the successor to the NNIN.
- Research Resources (+$1.01 million to a total of $5.01 million): This includes support for ChemMatCARS at Argonne National Laboratory (+$270,000 to a total of $970,000), consistent with the renewal award funding level, and adds support for highly meritorious Major Research Instrumentation proposals (+$1.50 million to a total of $3.50 million).

DIVISION OF MATERIALS RESEARCH (DMR)

$315,800,000
+$8,810,000 / 2.9%

DMR Funding

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, DMR	**$267.09**	**$306.99**	**$315.80**	**$8.81**	**2.9%**
Research	**201.60**	**251.91**	**248.54**	**-3.37**	**-1.3%**
CAREER	25.11	21.22	23.03	1.81	8.5%
Centers Funding (total)	32.78	62.89	60.34	-2.55	-4.1%
Materials Centers[1]	24.82	56.00	56.00	-	-
Nanoscale Science & Engineering Centers	0.77	0.25	0.25	-	-
STC1: Center for Layered Polymeric Materials	3.32	2.66	-	-2.66	-100.0%
STC2: Center for Integrated Quantum Materials	3.87	3.98	4.09	0.11	2.8%
Education	**6.80**	**6.30**	**5.76**	**-0.54**	**-8.6%**
Infrastructure	**58.69**	**48.78**	**61.50**	**12.72**	**26.1%**
National High Magnetic Field Laboratory (NHMFL)	38.68	24.04	32.78	8.74	36.4%
Center for High Resolution Neutron Scattering (CHRNS)	2.66	2.66	2.66	-	-
Cornell High Energy Synchrotron Source (CHESS)	10.00	10.00	10.00	-	-
National Nanotechnology Coordinated Infrastructure (NNCI)	-	2.58	2.58	-	-
National Nanotechnology Infrastructure Network (NNIN)	2.58	-	-	-	N/A
Research Resources	4.77	1.50	1.00	-0.50	-33.3%
Mid-scale Research Infrastructure	-	8.00	12.48	4.48	56.0%

Totals may not add due to rounding.

[1] Due to end-of-fiscal year deadlines, $29.81 million in funding for new Materials Center awards was carried over from FY 2014 and obligated in early FY 2015.

Research in DMR focuses on advancing materials discovery and characterization. Programs focus on condensed matter physics, solid-state chemistry, and the science of materials that are multifunctional, hybrid, electronic, photonic, metallic, superconducting, ceramic, polymeric, biological, and nano-structured. DMR awards enable materials scientists to advance understanding of the electronic, atomic, and molecular mechanisms and processes that govern macroscale properties. The community seeks to manipulate and control these properties, discover and understand emerging phenomena, and create novel synthesis and processing strategies that lead to new materials with unique characteristics. These discoveries and advancements transcend traditional scientific and engineering disciplines. They enable new technologies that meet societal needs, including those with the goal of sustainability. Research supported by DMR is essential for the development of future technologies and industries including clean energy, advanced optics and electronics, and health. A key and critical enabler to these scientific advances is the investment in development and support of the materials workforce, cyberinfrastructure, and next generation instruments and facilities, including support for mid-scale user facilities called Materials Innovation Platforms (MIP). A MIP, in addition to developing and providing access to new instrumentation, conducts research on a materials challenge by integrating synthesis, characterization, and materials theory or modeling. Finally, conveying the exciting science and the societal benefit enabled by

materials research to students and to the general public remains an important aspect of the division's mission.

In general, 35 percent of the DMR portfolio is available for new research grants and 65 percent goes to continuing grants.

FY 2016 Summary

All funding decreases/increases represent change over the FY 2015 Estimate.

Research

- CAREER (+$1.81 million to a total of $23.03 million): DMR places high priority on these grants in order to develop a pipeline of new faculty in materials research who will help form the community of the future. This increase will fund about 14 additional awards.
- DMR participates in the CEMMSS Initiative through investments in Designing Materials to Revolutionize and Engineer our Future (DMREF) (+$5.25 million to a total of $12.25 million), a program DMR is leading in response to the national Materials Genome Initiative, and Advanced Manufacturing (+$6.07 million to a total of $23.67 million) through individual investigator programs, MRSEC investments, and participation in the Sustainable Nanomanufacturing solicitation. DMREF is a major effort to accelerate the discovery and deployment of new materials with a specific and desired function or property through synergistic integration of theory and computation, experiments, and systematic use of materials data.
- SEES: DMR contributes to this cross-agency initiative (-$1.0 million to a total of $6.0 million) through participation in the Sustainable Chemistry, Engineering and Materials (SusChEM) program. DMR focuses this research on the preservation and extension of natural resources aimed at improved material usage and overall lifecycle management. The decrease reflects the planned sunset of SEES in 2017.
- Clean energy (+$60,000 to a total of $70.12 million): Additional research in the DMR clean energy portfolio includes hydrogen, fuel cells, biomass, solar energy, hydrocarbon conversion, the capture and use of CO_2, and energy storage.
- BioMaPS (+$260,000 to a total of $3.24 million): DMR supports a large and growing amount of research in this area, not only in its Biomaterials program, but throughout the portfolio including the centers and facilities.
- Understanding the Brain (+$250,000 to a total of $3.80 million): DMR increases support this agency-wide focus in brain-related research.
- CIF21 (+$800,00 to a total of $2.65 million): DMR will accelerate research, especially related to CEMMSS/DMREF, by investing in new functional capabilities in computational methods, algorithms, tools and data core methods, and technologies.
- Materials Research Science and Engineering Centers (MRSECs) (no change at $56.0 million): MRSEC competitions are usually held triennially, the last in FY 2014 with awards made in early FY 2015. In FY 2016, 21 new and continuing awards are expected to be supported.
- Nanoscale Science and Engineering Centers (NSECs): Support remains unchanged for the NSEC program, which is winding down agency-wide as planned.
- Science and Technology Centers (-$2.55 million to a total of $4.09 million): Funding reflects the planned sunsetting of the Center for Layered Polymeric Systems (-$2.60 million to zero) and a ramp up in support for the Center on Integrated Quantum Materials (+$110,000 for a total of $4.09 million).

Education

- Research Experiences for Undergraduates (-$300,000 to a total of $5.17 million): DMR's education portfolio maintains commitments to this program but with a small reduction.
- Integrative Graduate Education and Research Traineeship (-$240,000 to a total of $160,000): Support decreases as the program is sunsetting as planned.

Infrastructure

- Mid-scale Research Infrastructure (+$4.48 million to a total of $12.48 million): Funding supports the Material Innovation Platforms (MIP) program started in FY 2015. The MIP program, which includes a user program, focuses on technical priorities for advancing materials research and is comprised of specialized instrumentation and computation for characterization, modeling, synthesis, and processing for new materials.
- Research Resources (-$500,000 to a total of $1.0 million): Funding for helium reclamation decreases due to less demand from the community.
- National Nanotechnology Coordinated Infrastructure (NNCI) (no change at $300,000): Funds are requested for DMR's contribution to NNCI, the successor to the National Nanotechnology Infrastructure Network (NNIN).
- National High Magnetic Field Laboratory (NHMFL) (+$8.74 million to a total of $32.78 million): Funding continues transformational research using high magnetic fields. This facility serves researchers in fields ranging from biology to materials and condensed matter physics. In FY 2014, DMR forward funded NHMFL by $7.79 million, reducing the amount required in FY 2015. In FY 2016, funding returns to the level committed to in the current cooperative agreement.

DIVISION OF MATHEMATICAL SCIENCES (DMS) $235,470,000
+$3,740,000 / 1.6%

DMS Funding
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, DMS	**$224.97**	**$231.73**	**$235.47**	**$3.74**	**1.6%**
Research	**197.95**	**218.15**	**227.82**	**9.67**	**4.4%**
CAREER	12.31	9.51	10.03	0.52	5.5%
Centers Funding (total)	0.20	0.10	0.20	0.10	100.0%
Centers for Analysis & Synthesis	0.20	0.10	0.20	0.10	100.0%
Education	**27.02**	**13.58**	**7.65**	**-5.93**	**-43.7%**

Totals may not add due to rounding.

DMS plays a critical role in providing more than 50 percent of all U.S. federal support basic research at the frontiers of discovery in the mathematical sciences.

The influence of mathematical sciences on daily life is fundamental and pervasive; for example, every secure commercial transaction on the internet is an application of research in number theory and algebraic geometry. Modern communication, transportation, medicine, manufacturing, security, and finance all depend on developments in the mathematical sciences.

DMS investments catalyze research at the frontiers of fundamental, applied, and computational mathematics and statistics, and also enable discovery and innovation in other fields of science and engineering linked to key national priorities. In turn, advances in science and engineering inspire development of ever more sophisticated mathematical and statistical methodology, theory, and tools. DMS investments underpin these developments as well as the training of future researchers in the mathematical sciences.

In addition to supporting a vibrant research community through core research programs in mathematics and statistics, DMS supports national mathematical sciences research institutes that advance research, increase the impact of the mathematical sciences, respond to national needs, and expand the U.S. talent base engaged in mathematical and statistical research. DMS also continues to develop interdisciplinary activities that reflect national priorities. Successful multi-agency programs, such as joint activity in biosciences with the National Institute of General Medical Sciences, are continuing, and newer DMS activities, such as the Mathematical Sciences Innovation Incubator and the Computational and Data-Enabled Science and Engineering program, are attracting broad interest. The DMS Workforce Program offers funding opportunities that support efforts to increase the number of well-prepared students who pursue careers in the mathematical sciences and in other NSF-supported disciplines. These investments in mathematical sciences discovery, connections, and community are essential components of the innovation engine that drives the nation's economy in the 21st century.

In general, 48 percent of the DMS portfolio is available for new research grants and 52 percent is available for continuing grants.

FY 2016 Summary

All funding decreases/increases represent change over the FY 2015 Estimate.

Research

- CAREER (+$520,000 to a total of $10.03 million): Support for early-career researchers is a division priority. This increase allows DMS to support two to three additional CAREER awards.
- Optics and photonics (+$3.60 million to a total of $4.60 million): Divisional investment in this emphasis area reflects increased interest in this important area. DMS will lead MPS participation in this multidisciplinary NSF-wide activity to invest in fundamental research in optics and photonics, which are key enabling technologies in a multitude of application areas. DMS will coordinate MPS activities in optics and photonics in collaboration with other participating directorates. The activity will be highlighted through community workshops and the development of a program solicitation.
- BioMaPS (+$260,000 to a total of $3.26 million): DMS invests in innovative research at the intersection of the mathematical and physical sciences and the biological sciences in a comprehensive approach to acquire insight into and inspiration from the living world.
- Understanding the Brain (+$1.75 million to a total of $5.30 million): DMS support increases in this NSF goal to enable scientific understanding of the full complexity of the brain, in action and in context, through targeted, cross-disciplinary investments.
- Secure and Trustworthy Cyberspace (+$1.0 million to a total of $1.50 million): Funding reflects increased national need for fundamental cybersecurity research. This research investigates questions surrounding securing information networks against hostile intrusion and ensuring individual privacy in anonymized data sets.
- CEMMSS (+$1.73 million to a total of $6.10 million): Funding will accelerate fundamental discoveries in materials science by investing in new capabilities for mathematical modeling, computational simulation, numerical algorithms, and data analysis and management.
- SEES (-$2.50 million to zero): Decreased investment here is offset by DMS investment in new interdisciplinary research, including Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS) (+$1.70 million to $1.70 million total) and Risk and Resilience (+$500,000 to a total of $500,000). Research on fundamental scientific issues, such as understanding the dynamical processes that produce extreme events, will advance knowledge and help to create tools for increased resilience of societal infrastructure to natural and man-made hazards.
- Mathematical Sciences Research Institutes (level at $29.50 million): Eight domestic DMS-supported institutes will continue to catalyze frontier research through an array of scientific programs.

Education

- Decreased investment in the overall Education portfolio (-$5.93 million to a total of $7.65 million in FY 2016) reflects the mainstreaming into core programs of support for graduate students and postdoctoral researchers. Most of these decreases are achieved through the sunset of the Enhancing the Mathematical Sciences Workforce in the 21st Century program.
- The Education portfolio maintains a commitment to Research Experiences for Undergraduates (REU) program at $3.39 million.
- Mathematical Sciences Postdoctoral Research Fellowships (level at $4.10 million): DMS continues investments in a number of education and diversity activities through the program.

DIVISION OF PHYSICS (PHY) $277,370,000
+$2,380,000 / 0.9%

PHY Funding
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, PHY	**$267.09**	**$274.99**	**$277.37**	**$2.38**	**0.9%**
Research	**163.82**	**176.05**	**176.19**	**0.14**	**0.1%**
CAREER	8.57	7.44	7.45	0.01	0.1%
Centers Funding (total)	0.02	0.02	-	-0.02	-
Nanoscale Science & Engineering Centers	0.02	0.02	-	-0.02	-
Education	**5.38**	**5.56**	**5.32**	**-0.24**	**-4.3%**
Infrastructure	**97.89**	**93.38**	**95.86**	**2.48**	**2.7%**
IceCube Neutrino Observatory	3.45	3.45	3.45	-	-
Large Hadron Collider (LHC)	17.37	18.00	18.00	-	-
Laser Interferometer Grav. Wave Obs. (LIGO)	36.43	39.43	39.43	-	-
National Superconducting Cyclotron Laboratory (NSCL)	22.50	22.50	22.50	-	-
Research Resources	11.56	-	-	-	N/A
Mid-scale Research Infrastructure	6.58	10.00	12.48	2.48	24.8%

Totals may not add due to rounding.

PHY supports fundamental research addressing frontier areas of physics that lead to the understanding of the make-up of the Universe, from the formation of stars and galaxies to the principles of life processes on Earth. This research covers a range of physics subfields: atomic, molecular, optical and plasma physics, elementary particle physics, gravitational physics, nuclear physics, particle and nuclear astrophysics, physics of living systems, physics at the information frontier, and theoretical physics. PHY is the primary supporter of all U.S. research in gravitational physics and the leading supporter of fundamental research in atomic, molecular, and optical physics in the U.S. PHY is a major partner with DOE in support of elementary particle physics, nuclear physics, and plasma physics. PHY also has the only U.S. program designed for the support of physics research in living systems. The development of the most advanced cutting-edge computational resources, innovative technology, and new instrumentation is a key part of physics research, and tools developed by the physics community continuously have major impact in other scientific and engineering fields.

In general, 22 percent of the PHY portfolio is available for new research grants. The remaining 78 percent is used primarily to fund continuing grants made in previous years (49 percent) and to support operations and maintenance for four facilities that are a key part of the division portfolio (29 percent).

FY 2016 Summary

All funding decreases/increases represent change over the FY 2015 Estimate level.

Research

- Added funding for research grants will support additional individual investigator awards. Changes in NSF-wide investments are accommodated through strategic funding through PHY core programs.

These include:

- BioMaPS (+$260,000 million to a total of $3.26 million): This provides for programs that support research at the interface between the mathematical and physical sciences and the life sciences.
- Understanding the Brain (+$2.05 million to $5.80 million): This provides support for physics-based research that enables scientific understanding of the full complexity of the brain.
- CIF21 (+$800,000 to a total of $2.65 million): Additional funding for the extremely successful Computational and Data-Enabled Science and Engineering (CDS&E) portion of the CIF21 initiative.

Education

- Research Experiences for Undergraduates Sites and Supplements program (REU) (level at $5.06 million): $100,000 of this funding will support enhanced research experiences for students in their first two years of college, as recommended by the President's Council of Advisors on Science and Technology (PCAST) in their 2014 report, *Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics.*[12] In addition, $650,000 will support efforts to broaden participation by groups traditionally underrepresented in the physical sciences.

Infrastructure

- Large Hadron Collider (level at $18.0 million): This supports operations of the ATLAS and CMS detectors at LHC.
- Laser Interferometer Gravitational Wave Observatory (level at $39.43 million): This supports operations of LIGO and commissioning of its upgraded interferometer following completion of the Advanced LIGO construction project.
- National Superconducting Cyclotron Laboratory (level at $22.50 million): This supports operations of the NSCL at Michigan State University.
- Mid-scale Research Infrastructure (+$2.48 million to a total of $12.48 million): Funding supports instrumentation for high-priority experiments that cannot be accommodated within individual program budgets.

[12] www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-executive-report-final_2-13-12.pdf

OFFICE OF MULTIDISCIPLINARY ACTIVITIES (OMA) $39,840,000
+$4,840,000 / 13.8%

OMA Funding

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, OMA	**$35.17**	**$35.00**	**$39.84**	**$4.84**	**13.8%**
Research	**34.43**	**31.89**	**33.17**	**1.28**	**4.0%**
CAREER	0.92	-	-	-	N/A
Education	**0.74**	**3.11**	**6.67**	**3.56**	**114.5%**

Totals may not add due to rounding.

OMA enables and facilitates MPS support of novel, challenging, or complex projects of varying scale, in both research and education, which are not readily accommodated by traditional organizational structures and procedures. This is done primarily in partnership with MPS disciplinary divisions and is especially directed at activities by multi-investigator, multidisciplinary teams, as well as cross-NSF and interagency activities.

In general, approximately 62 percent of the OMA portfolio is available for new research grants and 38 percent is available for continuing grants.

In FY 2016, OMA will focus on multidisciplinary research that emphasizes the mathematical and physical scientific foundations of sustainability, including issues that affect food systems and the nexus of food, energy, and water; fundamental science critical to the discovery, understanding, and development of new materials; basic research at the interface between the mathematical and physical sciences and the life sciences that will lead to new insights into the molecular basis of life processes and to a better understanding of the healthy human brain and that of model animal species; computational and data-enabled science across the MPS divisions; multidisciplinary explorations in optics and photonics, including light-matter interaction at the nanoscale that encompass materials, devices, and systems; the understanding, control, and manipulation of the behavior of quantum matter and the limitations of quantum information processing; and team efforts aimed at the development of next-generation instrumentation to enable fundamental advances across a wide spectrum of disciplines. OMA also will provide leadership and support for INSPIRE and I-Corps™ activities within MPS.

MPS divisions have undertaken, or are engaged in, wide ranging reviews of their facilities portfolios. Of particular note is the portfolio analysis carried out by the MPS Advisory Committee, which is addressed further in the AST division narrative.

FY 2016 Summary

All funding decreases/increases represent change over the FY 2015 Estimate.

Research

- In FY 2016, OMA will focus on multidisciplinary research that addresses the key MPS and NSF-wide priority areas of optics and photonics, INFEWS, CIF21, CEMMSS, BioMaPS, clean energy, Understanding the Brain, INSPIRE, and I-Corps™.
- I-Corps™ (+$700,000 to a total of $1.70 million): This investment nearly doubles, primarily to support I-Corps™ teams. Investments are directed to an assessment of the commercial viability of the scientific discoveries in MPS disciplines through the individual investigator award program.
- INSPIRE: No change at $3.0 million.
- CIF21: OMA will continue to coordinate MPS' participation with BIO, CISE, and ENG.

Education

- OMA will contribute $400,000 to the Career-Life Balance supplements.
- OMA will provide the entire NRT contribution of $3.65 million (+$1.14 million) for the MPS directorate.

Facilities

- OMA will invest up to $7.0 million (no change) in FY 2016 to support responsible decisions regarding implementation of portfolio analysis recommendations. This investment will support studies of possible environmental issues, stewardship transition costs, or partnership start-up costs.

DIRECTORATE FOR SOCIAL, BEHAVIORAL AND ECONOMIC SCIENCES (SBE)

$291,460,000
+$19,260,000 / 7.1%

SBE Funding
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Social and Economic Sciences (SES)	$95.87	$97.72	$105.13	$7.41	7.6%
Behavioral and Cognitive Sciences (BCS)	93.10	94.47	101.79	7.32	7.7%
National Center for Science and Engineering Statistics (NCSES)	39.73	50.76	54.31	3.55	7.0%
SBE Office of Multidisciplinary Activities (SMA)	28.14	29.25	30.23	0.98	3.4%
Total, SBE	**$256.84**	**$272.20**	**$291.46**	**$19.26**	**7.1%**

Totals may not add due to rounding.

About SBE

SBE's mission is to promote the understanding of people and their lives by supporting research that reveals basic facets of human behavior; to encourage research that addresses important societal questions and problems; to work with other scientific disciplines ensuring that basic research and solutions to problems build upon the best multidisciplinary science; and to provide mission-critical statistical information about science and engineering (S&E) in the U.S. and the world through the National Center for Science and Engineering Statistics (NCSES). SBE supports long-term research across a diverse range of sciences that includes anthropology, archaeology, economics, geography, linguistics, neuroscience, political science, psychology, sociology, and statistics. SBE combines these sciences in interdisciplinary activities linking these fields to each other and to other science and engineering fields. SBE is a significant partner in cross-directorate programs that connect the social and behavioral sciences to priority investments across the agency.

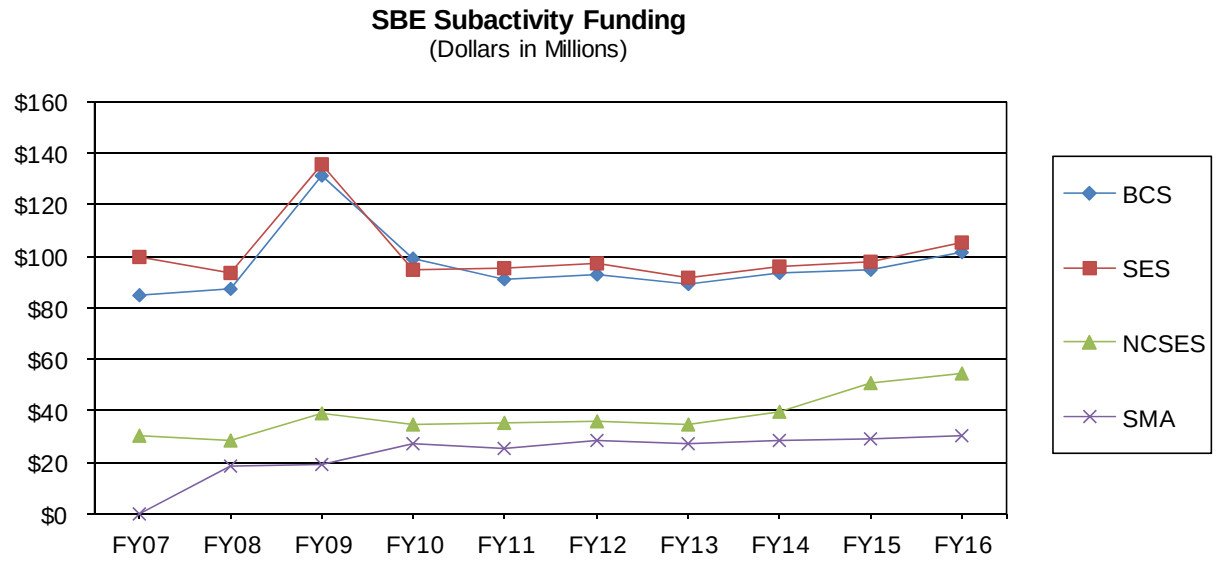
SBE's FY 2016 Request is informed by three key priorities: (1) enhancing research investments that advance fundamental knowledge in the social, behavioral, and economic sciences broadly; (2) sustaining the directorate's ongoing strategic transformation through support for interdisciplinary research and training; and (3) participating in cross-directorate and NSF-wide priority activities in which a comprehensive understanding of human behavior – at the individual, group, and/or organizational level, across different scales of space and time – is central. In addition, SBE is home to NCSES, the Nation's leading provider of statistical data on the S&E enterprise. NCSES collects and analyzes data on research and development, the S&E workforce, the condition and progress of Science, Technology, Engineering, and Mathematics (STEM) education, and U.S. competitiveness in science, engineering, technology, and research and development.

SBE's budget plan for FY 2016 includes terminations in several investments and subsequent redeployment of the recovered resources to other cross-directorate and NSF-wide priority activities. The graduation of the final cohort of Science of Learning Centers (SLCs) after ten years of support frees up resources that will be invested in a number of other initiatives in FY 2016. These include the Science of Learning program, initiated in FY 2015, and Understanding the Brain (UtB), which includes cognitive science, neuroscience, and the BRAIN Initiative. In FY 2016, SBE will terminate its investment in Science, Engineering, and Education for Sustainability (SEES) as that program continues to ramp down.

This will allow SBE to make an initial investment in the new NSF-wide Innovation at the Nexus of Food, Energy, and Water Systems (INFEWS) portfolio. SBE will continue to invest in the Critical Resilient Interdependent Infrastructure Systems and Processes (CRISP) program, which focuses on the key social and behavioral research questions that are relevant for understanding risk and resilience of both designed and natural systems and of individuals interacting within and affected by these systems. Finally, SBE will invest in the NSF-wide effort to increase participation of underrepresented groups in STEM fields, the Inclusion across the Nation of Communities of Learners that have been Underrepresented for Diversity in Engineering and Science (NSF INCLUDES) program.

SBE's FY 2016 Request includes increased investment to support new projects in NCSES. The increased investment will be used to support (1) development of enhanced data access tools, techniques, and visualizations; (2) new data collection techniques building on administrative data and other "big data" sources; and (3) questionnaire redesign and survey improvements supporting current research and policy community needs, such as improved data on pathways for scientists and engineers and measures of innovation.

SBE provides about 64 percent of the federal funding for basic research at academic institutions in the social, behavioral, and economic sciences.



FY 2009 funding reflects both the FY 2009 omnibus appropriation and funding provided through the American Recovery and Reinvestment Act of 2009 (P.L. 111-5).

FY 2016 Summary by Division

- SES's FY 2016 Request reflects its strong contribution to the unifying themes in the FY 2016 NSF Budget Request. This includes an initial investment in two new activities: the NSF-wide INFEWS program and the emerging Urban Science activity. SES will also: increase investments in Cyberinfrastructure Framework for 21st Century Science, Engineering, and Education (CIF21) to address critically important issues related to reproducibility, data access, and privacy; increase support for CRISP as part of the Risk and Resilience investment; and sustain investment in Secure and Trustworthy Cyberspace (SaTC) through the Cyber Economic Incentives theme within Control,

Networks, & Computational Intelligence (CNCI). SES will continue efforts to build the scientific foundation and research evidence base needed for future programmatic efforts in broadening the participation of women, underrepresented minorities, and people with disabilities in S&E (via SBE's Science of Broadening Participation (SBP) and investment in the new NSF INCLUDES program). SES will maintain its commitment to existing programs and continue support for surveys that provide unique insights into U.S. social, economic, and political life while providing funding for new research that has the potential to transform the social and economic sciences and contribute to effective policy development. SES will increase funding for the Faculty Early Career Development program (CAREER). To enhance interdisciplinary research and training, SES will participate in the Interdisciplinary Behavioral and Social Science Research (IBSS) program. SES will maintain investment in the National Nanotechnology Coordinated Infrastructure (NNCI), the successor to the National Nanotechnology Infrastructure Network (NNIN).

- In FY 2016, BCS will be a major partner in two new interdisciplinary activities: the NSF-wide INFEWS emphasis and the emerging multi-directorate Urban Science activity. BCS will invest in CRISP as part of the Risk and Resilience portfolio. BCS will increase investments in Understanding the Brain, CIF21, and CAREER, and will continue its investment in the Science of Learning. BCS will expand support for behavioral, cognitive, anthropological, and geographic research that informs understanding of critical issues facing the Nation, such as terrorism, pandemics, sustainability, and forensic science. In its ongoing programs, BCS will operate in an interdisciplinary context, providing support for research on the complex ways people think, adapt, and interact with social, natural, and built environments. BCS support for CNCI will enable research about cognitive and behavioral aspects of threats to cybersecurity. BCS will continue efforts to broaden the participation of women, underrepresented minorities, and people with disabilities in science and engineering via SBE's Science of Broadening Participation (SBP) and investment in the new NSF-wide NSF INCLUDES program. BCS will continue to participate in the IBSS program to enhance interdisciplinary research and training. BCS will continue to fund basic research that advances understanding of cognition and behavior through various research mechanisms.

- For FY 2016, NCSES will maintain its core programmatic data collection and publication activities. NCSES will initiate new projects that support (1) development of enhanced data access tools, techniques, and visualizations including a new interface to the Scientists and Engineers Statistical Data System (SESTAT) and WebCASPAR, a database that provides easy access to a large body of statistical data resources for S&E at U.S. academic institutions; (2) new data collection techniques building on administrative data and other "big data" sources and expanding standardized tagging efforts; and (3) questionnaire redesign and survey improvements to support improved data on measures of innovation and educational and career pathways for scientists and engineers. Additionally, NCSES will continue to pursue significant and strategic targeted improvements, which began in FY 2015, in its statistical and analytic programs. NCSES will continue to develop and test new measures from the Survey of Doctorate Recipients (SDR) that address data gaps related to understanding the relationship between federal support for graduate education and student outcomes, such as employment. NCSES will continue work to close a growing gap in its national estimates for research and development by fielding a survey of nonprofit organizations. NCSES will expand the scope of administrative records sources that could potentially augment its existing surveys and will implement a pilot project establishing collaboration among several federal agencies to assess the feasibility of using agencies' administrative records to measure research and development (R&D) activity, with a longer-term goal towards developing a common repository for government-wide R&D information. Responding to recommendations in the Committee on National Statistics report, *Capturing Change in Science, Technology and Innovation,*[1] NCSES will develop and test potential

[1] www.nap.edu/catalog/18606/capturing-change-in-science-technology-and-innovation-improving-indicators-to

indicators of innovation. To better answer questions about new or emerging science and technology (S&T) topics and provide a flexible format for testing new questions for the Center's surveys, NCSES will design and test the capacity to collect small, quick turnaround survey data. Throughout, NCSES will work to improve international comparability, particularly on the S&E workforce.

- SMA provides a focal point for programmatic activities that cut across NSF and SBE boundaries. In addition, SMA assists with seeding interdisciplinary activities for the future. In FY 2016, SMA will increase investment in the Science of Learning, building on the momentum generated by the Science of Learning Centers that will have graduated and the Science of Learning Collaborative Networks initiated in FY 2015. SMA will increase investment in Understanding the Brain and CIF21. SMA will continue to play an important role in the expansion of interdisciplinary training and broadening participation as part of SBE 2020, with continued support and management of the SBE Postdoctoral Research Fellowships (SPRF) program. Support for enhancing the research experience for students will continue via sustained investments in the Research Experiences for Undergraduates (REU) Sites and Supplements programs. SMA will continue support of interdisciplinary activities associated with the Science of Science and Innovation Policy program (SciSIP), as well as efforts to make NSF-funded research available to the public through the Public Access Initiative. SMA will participate in NSF Innovation Corps (I-Corps™), Integrated NSF Support Promoting Interdisciplinary Research and Education (INSPIRE), and SaTC (through the Cyber Economic Incentives theme within CNCI, a multi-agency priority).

SBE Major Investments
(Dollars in Millions)

Area of Investment	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
CAREER	$7.89	$7.84	$8.34	$0.50	6.4%
CIF21	6.00	6.00	7.26	1.26	21.0%
I-Corps™	0.35	0.50	0.50	-	-
NSF INCLUDES	-	-	0.50	0.50	N/A
INFEWS	-	-	5.00	5.00	N/A
INSPIRE	0.02	1.00	1.00	-	-
NRT[1]	3.38	2.52	3.12	0.60	23.8%
Public Access Initiative	1.45	1.75	1.75	-	-
Risk and Resilience	-	2.00	8.50	6.50	325.0%
Science of Learning	-	5.00	7.00	2.00	40.0%
SciSIP	10.56	11.05	11.05	-	-
SEES	3.01	3.50	-	-3.50	-100.0%
SaTC	4.20	4.00	4.00	-	-
Understanding the Brain	20.56	22.00	25.00	3.00	13.6%
Urban Science	-	-	2.00	2.00	N/A

Major investments may have funding overlap and thus should not be summed.

[1] Outyear commitments for Integrative Graduate Education and Research Traineeship (IGERT) are included in the NRT line and are $3.38 million in FY 2014, $420,000 in FY 2015, and $2.62 million in FY 2016.

- CAREER: SBE supports CAREER (+$500,000 to a total of $8.34 million) with awards to young investigators in social and behavioral sciences who exemplify the role of teacher-scholar through the integration of education and research.

- CIF21: Funds (+$1.26 million, to a total of $7.26 million) will continue to support development of

user-friendly, large-scale, next-generation data resources and relevant analytical techniques to advance fundamental SBE research through increased investment in the Resource Implementations for Data Intensive Research in the Social, Behavioral, and Economic Sciences (RIDIR) program. SBE will enhance its investments in Data Science Pilots, in collaboration with the Division of Advanced Cyberinfrastructure (ACI) within the Directorate for Computer and Information Sciences and Engineering (CISE), to address critically important issues related to reproducibility and data access.

- I-Corps™: SBE will maintain its investment of $500,000 in continuing support of a multiyear effort to strengthen collaboration between SBE scientists in academia and the technological, entrepreneurial, and business communities and practitioners.

- NSF INCLUDES: SBE will make an initial investment of $500,000 in a new NSF-wide effort to increase participation of underrepresented groups in STEM fields, beginning with the NSF INCLUDES program.

- INFEWS: SBE will make an initial investment of $5.0 million in this NSF-wide initiative to enhance capacity to explore the interactions among food, energy, and water systems.

- INSPIRE: SBE will maintain its investment of $1.0 million in INSPIRE.

- NSF Research Traineeship (NRT): In FY 2016, SBE will decrease participation (-$1.60 million, to a total of $500,000) in the NSF-wide NRT program, which is the successor to the Integrative Education and Research Traineeship (IGERT) program.

- Public Access Initiative: Continued investment of $1.75 million will further NSF's efforts, which began in FY 2013, to make the results of the NSF-funded research available to the public. This initiative aligns with OSTP policy memorandum, "Increasing Public Access to the Results of Federally Funded Scientific Research."

- Risk and Resilience: SBE will increase investment (+$6.50 million to a total of $8.50 million) in CRISP to focus on the key social and behavioral research questions that are relevant for interdisciplinary perspectives on risk and resilience of social, designed, and natural systems.

- Science of Learning: SBE will increase investment (+$2.0 million to a total of $7.0 million) in the Science of Learning, building on the momentum generated by the Science of Learning Centers (SLCs) that will have graduated and the Science of Learning Collaborative Networks initiated in FY 2015. Funding from the sunsetted SLC program (-$5.38 million total) will be redeployed to support this increased investment in the Science of Learning and to increase support for Understanding the Brain.

- Science of Science and Innovation Policy (SciSIP): SciSIP funding is held constant with the FY 2015 Estimate at $11.05 million. SciSIP will continue to support research and data collections related to innovation and R&D spending.

- SEES: In FY 2016, SBE will terminate (-$3.50 million) its investment in Science, Engineering, and Education for Sustainability (SEES) as that program ramps down.

- SaTC: SBE will sustain investment ($4.0 million) in Secure and Trustworthy Cyberspace (SaTC) through the Cyber Economic Incentives theme within CNCI.

- Understanding the Brain: SBE's investments in cognitive science/neuroscience and the BRAIN Initiative will increase (+$3.0 million, to a total of $25.0 million), in support of Administration and Congressional priorities, enhancing efforts to gain an integrative and comprehensive understanding of the brain and its function in context and in action. SBE will enhance support of research in cognitive science at the interface of computational and engineering science and education research.

- Urban Science: SBE will make an initial investment of $2.0 million in the Urban Science program. In partnership with CISE and the Directorate for Engineering (ENG), SBE will support research that addresses organizational, social, psychological, political, geographic, and economic issues associated with rapidly developing and evolving smart city ecosystems.

SBE Funding for Centers Programs and Facilities

SBE Funding for Centers Programs
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, Centers Programs	**$15.07**	**$5.98**	**$0.60**	**-$5.38**	**-90.0%**
Nanoscale Science & Engineering Centers (BCS, SES)	1.17	0.60	0.60	-	-
Science of Learning Centers (BCS, SMA)	13.90	5.38	-	-5.38	-100.0%

Totals may not add due to rounding.

For detailed information on individual centers, please see the NSF-Wide Investments chapter.

- The Science of Learning Centers (SLC) program funding terminates (-$5.38 million) as the six existing centers will have reached the conclusion of their ten-year funding cycle by the end of FY 2015.

SBE Funding for Facilities
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, Facilities	**-**	**$0.40**	**$0.40**	**-**	**-**
National Nanotechnology Coordinated Infrastructure (NNCI)	-	0.40	0.40	-	-
National Nanotechnology Infrastructure Network (NNIN)	0.40	-	-		

Totals may not add due to rounding.

For detailed information on individual facilities, please see the Facilities chapter.

Summary and Funding Profile

SBE supports investments in core research and education as well as research infrastructure. In FY 2016, the number of research grant proposals is anticipated to increase by about 100 and SBE expects to award

approximately 650 research grants. The average annualized award size is estimated to increase slightly over the FY 2015 Estimate and duration will be held constant.

In FY 2016, funding for centers accounts for about 0.20 percent of SBE's Request. Center funding decreases $5.38 million from the FY 2015 Estimate, and only includes support for the Nanoscale Science and Engineering Centers. FY 2016 funding for facilities accounts for less than one percent of SBE's Request, equal to FY 2015, and only includes support for the National Nanotechnology Coordinated Infrastructure.

SBE Funding Profile

	FY 2014 Actual Estimate	FY 2015 Estimate	FY 2016 Estimate
Statistics for Competitive Awards:			
Number of Proposals	4,507	4,800	5,000
Number of New Awards	995	1,120	1,140
Funding Rate	22%	23%	23%
Statistics for Research Grants:			
Number of Research Grant Proposals	3,203	3,300	3,400
Number of Research Grants	618	630	650
Funding Rate	19%	19%	19%
Median Annualized Award Size	$108,903	$109,000	$109,000
Average Annualized Award Size	$133,578	$144,900	$145,500
Average Award Duration, in years	2.6	2.6	2.6

Program Monitoring and Evaluation

Workshops and Reports:

- As the Science of Learning Centers graduate from NSF support, SBE, CISE, ENG, and the Directorate for Education and Human Resources (EHR) are launching the next phase of NSF investments in the Science of Learning in FY 2015 with the issuance of a new solicitation for proposals to create new collaborative networks of investigators to conduct exploratory, basic and/or translational research in the Science of Learning. This solicitation was informed by reports from the SBE Advisory Committee (AC) Subcommittee on the Future of the Science of Learning, several workshops held in 2012-2013, and the *International Convention on Science of Learning,*[2] which addressed how Science of Learning research can facilitate human learning, and inform educational practice and policy (co-organized by NSF, the Organization for Economic Cooperation and Development (OECD) and the United Nations Educational, Scientific, and Cultural Organization (UNESCO), in collaboration with the East China Normal University, Shanghai Normal University and the University of Hong Kong; March 2014). A February 2015 workshop, *Science of Learning: Integration and Synthesis,* will inform future Science of Learning activities and contribute to the program's overarching goal of creating, on a national scale, an integrated Science of Learning community.

- During FY 2015, SES plans examine the future trajectories for the three major ongoing social science surveys SES supports − the American National Election Studies (ANES), General Social Survey (GSS), and Panel Study of Income Dynamics (PSID). The 2014 report from the SBE AC

[2] http://sol.edu.hku.hk/international-convention-science-learning/

Subcommittee on Advancing SBE Survey Research will be supplemented by additional assessment to inform SES decisions about the support of social science surveys in FY 2016 and beyond.

- The SBE AC Subcommittee on Replicability in Science organized a workshop, *Robust Research in the Social, Behavioral, and Economic Sciences*, in February 2014 that brought together researchers, journal editors, science administrators, institutional administrators, and funding agency staff to discuss the challenge and make recommendations to address the issue of scientific replicability. The panels addressed the scope and magnitude of the problem; recommendations for scientific practice; education and training; editorial/journal policies and procedures; institutional policies and procedures; and funding agency opportunities and policies. The Subcommittee presented its draft report at the SBE AC meeting in October 2014. The report is currently under revision with release planned for spring of 2015, after which SBE will consider its recommendations and plan future activities.

- BCS and the Division of Physics within the Directorate for Mathematical and Physical Sciences (MPS) sponsored a workshop, *Quantitative Theories of Learning, Memory and Prediction,*[3] in May 2014. This workshop brought together experts in theoretical physics, computational modeling, data acquisition, and cognitive neuroscience to discuss and identify the next frontiers in theoretical models of higher order cognitive processes. The results of this workshop will inform the division's investments in Understanding the Brain.

- In December 2014, NCSES convened a panel of statisticians with expertise in survey sampling methods to review proposed plans and to determine the best strategy to expand the sample of the Survey of Doctorate Recipients (SDR). The input from the panel will be used to determine the best strategy to meet NCSES's near and longer-term objectives for the survey.

- In June of 2014, a Human Resources Expert Panel meeting was conducted to help NCSES's Human Resources Statistics Program assess two strategies for improving occupational history data that support a growing demand for research examining job mobility, occupational change, and career pathways of the S&E workforce. Panel results will help shape the Scientists and Engineers Statistical Data System, a unique source of information on the education and employment of the college-educated U.S. science and engineering workforce that are collected through two longitudinal biennial surveys – the National Survey of College Graduates and the Survey of Doctorate Recipients.

- In February of 2014, the National Academies Committee on National Statistics (CNSTAT) convened a first meeting of the project's appointed expert steering committee to consider the conceptual and design issues for a new NCSES survey of R&D performed and funded by U.S. nonprofit organizations and plan for a larger workshop on the topic in late 2014. This effort follows a recommendation received in a 2013 CNSTAT report. The findings and recommendations of this steering committee meeting served as key inputs for planning a June 30 – July 1, 2014 CNSTAT workshop, *Measuring Research and Development Expenditures in the U.S. Nonprofit Sector: Conceptual and Design Issues.*[4] The recommendations from these workshops are being used to help NCSES draft a pilot survey for nonprofit organizations, expected to be tested in early FY 2016.

- NCSES hosted an expert panel in September of 2014 to continue to assist the Research and Development Statistics Program (RDS) with the planning and design of the new survey of R&D within nonprofit organizations. The panel included those who direct or lead nonprofit organizations or their research operations, have expertise in survey methodology, or have expertise in nonprofit tax

[3] http://physicsoflivingsystems.org/workshops/learningmemoryprediction/
[4] http://sites.nationalacademies.org/DBASSE/CNSTAT/CurrentProjects/DBASSE_087257

data. The panelists' views and recommendations are being used to help NCSES draft the pilot survey, expected to be tested in late 2015.

- In December of 2014, NCSES convened an expert panel to identify and consider new avenues for refining, expanding, and reshaping the national innovation data NCSES presently collects. As part of the NCSES mission, NCSES is developing a series of projects regarding the measurement of innovation in the national economy. NCSES currently collects data on the incidences of innovation through the annual Business R&D and Innovation Survey and plans to include questions on this topic in the forthcoming Microbusiness Innovation Science and Technology survey.

Committees of Visitors (COV):

- In late FY 2015, a Committee of Visitors (COV) will review the SBE Office of Multidisciplinary Activities. The COV report and the division's response will be presented to the SBE AC in the spring of 2016.

- The SES COV convened June 3-5, 2013. The COV's report and the division's response to it was reviewed and approved by the SBE Advisory Committee in spring 2014. The next SES COV will convene in FY 2017.

- BCS will convene a COV in late FY 2015/early FY 2016 to review and evaluate its core programs and cross-directorate activities. The COV report and the division's response will be presented to the SBE AC in the spring of 2016.

The Performance chapter provides details regarding the periodic reviews of programs and portfolios of programs by external Committees of Visitors and directorate Advisory Committees. Please see this chapter for additional information.

Number of People Involved in SBE Activities

	FY 2014 Actual Estimate	FY 2015 Estimate	FY 2016 Estimate
Senior Researchers	1,878	2,000	2,200
Other Professionals	490	500	500
Postdoctorates	276	300	300
Graduate Students	1,857	2,000	2,000
Undergraduate Students	784	900	1,000
Total Number of People	**5,285**	**5,700**	**6,000**

DIVISION OF SOCIAL AND ECONOMIC SCIENCES (SES) $105,130,000
+$7,410,000 / 7.6%

SES Funding
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, SES	**$95.87**	**$97.72**	**$105.13**	**$7.41**	**7.6%**
Research	**83.83**	**87.80**	**94.76**	**6.96**	**7.9%**
CAREER	2.64	4.20	4.45	0.25	6.0%
Centers Funding (total)	0.99	0.42	0.42	-	-
Nanoscale Science & Engineering Centers	0.99	0.42	0.42	-	-
Education	**3.17**	**2.52**	**2.97**	**0.45**	**17.9%**
Infrastructure	**8.86**	**7.40**	**7.40**	**-**	**-**
National Nanotechnology Coordinated Infrastructure (NNCI)	-	0.40	0.40	-	-
National Nanotechnology Infrastructure Network (NNIN)	0.40	-	-	-	N/A
Research Resources	8.46	7.00	7.00	-	-

Totals may not add due to rounding.

SES supports research and related activities, conducted within the U.S. and globally, that improve understanding of economic, political, and social institutions and how individuals and organizations behave within them. SES funds activities investigating risk assessment and decision-making by individuals and groups; the nature and development of science and technology and their impact on society; methods and statistics applicable across the social, economic, and behavioral sciences; scholarly career development; and broadening participation in the social, behavioral, and economic sciences. Discipline-based programs include sociology, economics, and political science, while interdisciplinary programs support fields such as decision-making and risk management; law and social sciences; methods, measurement, and statistics; science of organizations; and science, technology, and society. In many of its programs, SES is the major, if not only, source of federal funding for fundamental research, making important investments in the data resources and methodological advances that produce transformative research.

In general, 71 percent of the total SES portfolio is available for new research grants and 29 percent is available for continuing grants.

FY 2016 Summary
All funding decreases/increases represent change over the FY 2015 Estimate.

Research
Overall, support for SES disciplinary and interdisciplinary research increases (+$6.96 million, to a total of $94.76 million).

- SES will increase support for Risk and Resilience through CRISP, which focuses on the key social and behavioral research questions that are relevant for interdisciplinary perspectives on risk and resilience of social, designed, and natural systems. SES support for this activity is increased by $3.25 million, to a total of $5.25 million.
- CAREER funding in FY 2016 increases by $250,000, to a total of $4.45 million. This investment is consistent with SES's emphasis on supporting early career researchers.

- CIF21 support increases by $730,000, to a total of $4.23 million, to support development of user-friendly, large-scale, next- generation data resources and relevant analytical techniques to advance fundamental SBE research through increased investment in the RIDIR program. SES will enhance its investments in Data Science Pilots, in collaboration with the Division of Advanced Cyberinfrastructure (ACI), within the Directorate for Computer and Information Sciences and Engineering (CISE), to address critically important issues related to reproducibility and data access.
- Support for SEES ends (-$2.0 million) as this program sunsets as planned.
- Support for interdisciplinary research, training, and integration opportunities through SBE 2020 (via SBE's IBSS program) is decreased by $750,000, to a total of $6.35 million.
- Continued support of $2.0 million for SaTC is provided through support for the Cyber Economic Incentives and other themes within CNCI.
- Funding for SES's Science of Broadening Participation (SBP) investment is maintained at the level of $750,000. This investment supports efforts to build the scientific foundation and research evidence base needed for future broadening participation efforts. Investing in research that informs the science of broadening participation spans education and the SBE sciences, and engages all of NSF.
- SES will make an initial investment of $2.50 million in INFEWS. This investment will enhance capacity to explore the interactions among water, food, and energy systems.
- SES will make an initial investment of $250,000 in the new NSF-wide effort to increase participation of underrepresented groups in STEM fields, beginning with the NSF INCLUDES activity.
- Funding for the Nanoscale Science and Engineering Centers (NSEC) will continue at $420,000.
- SES will make an initial investment of $1.0 million in the Urban Science activity. In partnership with ENG and CISE, and in cooperation with BCS, SES will support research that addresses organizational, social, psychological, political, and economic issues associated with rapidly developing and evolving smart city ecosystems.
- A general increase to core program investments of $4.24 million will result from a reinvestment of funds from concluded programs.

Education

- Support for the ADVANCE program is maintained at $600,000, and REU supplements ($500,000) remain constant with the FY 2015 Estimate level.
- In an effort to establish a better balance between the responsibilities and demands of work lives and family lives for social and behavioral scientists, SES will maintain its investment of $20,000 to support the Career-Life Balance (CLB) initiative.
- NRT and IGERT: SES FY 2016 funding for IGERT ($1.56 million total) supports continuing grant increments. In FY 2014, IGERT evolved into a new program, NRT, which encourages the development of bold, new, potentially transformative, and scalable models for STEM graduate training that ensure that graduate students develop the skills, knowledge, and competencies needed to pursue a range of careers within and outside academia. SES will invest $40,000 (a decrease of $64,000 from the FY 2015 Estimate) in NRT.

Infrastructure

- SES will invest $400,000 in NNCI, the successor to NNIN.
- SES research resources activities are funded at the FY 2015 Estimate, for a total of $7.0 million. Funding supports multi-million dollar survey awards such as the American National Election Studies (ANES), the Panel Study of Income Dynamics (PSID), and the General Social Survey (GSS). These surveys are national resources for research, teaching, and decision-making and have become models for similar undertakings in other fields. $2.0 million of the research resources funding supports SES' CIF21 investment inclusive of support for the RIDIR solicitation, which seeks to develop user-friendly, large-scale, next- generation data resources and relevant analytical techniques to advance fundamental SBE research.

DIVISION OF BEHAVIORAL AND COGNITIVE SCIENCES (BCS) — $101,790,000 +$7,320,000 / 7.7%

BCS Funding

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, BCS	**$93.10**	**$94.47**	**$101.79**	**$7.32**	**7.7%**
Research	**89.15**	**91.34**	**98.01**	**6.67**	**7.3%**
CAREER	5.22	3.64	3.89	0.25	6.9%
Centers Funding (total)	4.84	1.81	0.18	-1.63	-90.1%
Science of Learning Centers	4.66	1.63	-	-1.63	-100.0%
Nanoscale Science & Engineering Centers	0.18	0.18	0.18	-	-
Education	**2.64**	**1.99**	**2.64**	**0.65**	**32.7%**
Infrastructure	**1.31**	**1.14**	**1.14**	**-**	**-**
Research Resources	1.31	1.14	1.14	-	-

Totals may not add due to rounding.

BCS supports research and related activities that advance fundamental understanding in the behavioral, cognitive, anthropological, and geographic sciences. Strong core programs are complemented by active involvement in competitions that support collaborative and cross-disciplinary projects. The division seeks to advance scientific knowledge and methods focusing on human cognition and behavior, including perception, thought processes, language, learning, and social behavior across neural, individual, family, and group levels. BCS supports activities focusing on human variation at the scales of society, culture, and biology, and how these variations and related patterns develop and change across time and space. The division aims to increase basic understanding of geographic distributions and relationships as well as the capabilities to explore them, with an emphasis on interactions among human and natural systems on the Earth's surface. BCS research is helping to prepare for and mitigate the effects of natural and human-initiated disasters, predict and address how people respond to stressors, improve methods for effective learning, enhance the quality of social interaction, and respond to issues such as globalization, terrorism, and environmental change.

In general, 75 percent of the total BCS portfolio is available for new research grants and 25 percent is available for continuing grants.

FY 2016 Summary

All funding decreases/increases represent change over the FY 2015 Estimate.

Research

Overall, support for BCS disciplinary and interdisciplinary research increases (+$6.67 million to a total of $98.01 million).

- BCS will increase support for Risk and Resilience through CRISP, which focuses on the key social and behavioral research questions that are relevant for interdisciplinary perspectives on risk and resilience of social, designed, and natural systems. BCS support for this activity is initiated at $3.25 million.
- Increased support of $1.0 million, to a total of $18.60 million, for UtB will enhance efforts to gain an integrative and comprehensive understanding of the brain and its function in context and in action.
- CAREER funding in FY 2016 increases by $250,000, to a total of $3.89 million. This investment is consistent with BCS's emphasis on supporting early career researchers.

- CIF21 support increases by $340,000, to a total of $1.94 million, to support development of user-friendly, large-scale, next-generation data resources and relevant analytical techniques to advance fundamental SBE research through increased investment in the RIDIR program. BCS will enhance its investments in Data Science Pilots, in collaboration with CISE/ACI, to address critically important issues related to reproducibility and data access.
- Support for SEES ends (-$1.50 million) as this program ramps down as planned.
- Support for interdisciplinary research, training, and integration opportunities through SBE 2020 (via SBE's IBSS program) is decreased by $250,000, to a total of $4.15 million.
- BCS support for Cyberlearning and Future Learning Technologies is terminated (-$500,000).
- Continued support of $1.20 million for SaTC is provided through support for the Cyber Economic Incentives and other themes within CNCI.
- Funding for BCS's Science of Broadening Participation investment is maintained at the level of $750,000. This investment supports efforts to build the scientific foundation and research evidence base needed for future broadening participation efforts. Investing in research that informs the science of broadening participation spans education and the SBE sciences, and engages all of NSF.
- BCS will make an initial investment of $2.50 million in INFEWS. This investment will enhance capacity to explore the interactions between water, food, and energy systems.
- BCS will make an initial investment of $250,000 in the new NSF-wide effort to increase participation of underrepresented groups in STEM fields, beginning with the NSF INCLUDES activity.
- Support for the SLCs terminates (-$1.63 million) as all six of the existing centers will have reached the conclusion of their ten-year funding cycle by the end of FY 2015.
- BCS support ($4.0 million) for the Science of Learning will fund interdisciplinary research on the science of learning, with an overarching goal of creating, on a national scale, an integrated Science of Learning community.
- BCS will make an initial investment of $1.0 million in the Urban Science activity. In partnership with ENG and CISE, and in cooperation with SES, BCS will support research that addresses organizational, social, psychological, political, geographic and economic issues associated with rapidly developing and evolving smart city ecosystems.
- A general increase to core program investments of $2.37 million will result from a reinvestment of funds from concluded programs.

Education

- BCS support for the ADVANCE program is maintained at $400,000.
- REU supplements ($440,000) remain constant with the FY 2015 Estimate.
- In an effort to establish a better balance between the responsibilities and demands of work lives and family lives for social and behavioral scientists, BCS will maintain its investment of $30,000 to support the CLB initiative.
- NRT and IGERT: BCS FY 2016 funding for IGERT ($1.06 million) supports continuing grant increments. In FY 2014, IGERT evolved into a new program, NRT, which encourages the development of bold, new, potentially transformative, and scalable models for STEM graduate training that ensure that graduate students develop the skills, knowledge, and competencies needed to pursue a range of careers within and outside academia. BCS support for the NRT effort is decreased from the FY 2015 Estimate by $600,000, to a total of $460,000.

Infrastructure

- FY 2016 support for infrastructure activities is continued at $1.14 million. Funding supports BCS's CIF21 investment inclusive of support for the RIDIR competition, which seeks to develop user-friendly, large-scale, next- generation data resources and relevant analytical techniques to advance fundamental SBE research.

NATIONAL CENTER FOR SCIENCE AND ENGINEERING STATISTICS (NCSES) **$54,310,000**
+$3,550,000 / 7.0%

NCSES Funding

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Percent
Total, NCSES	**$39.73**	**$50.76**	**$54.31**	**$3.55**	**7.0%**
Research	**0.67**	**0.64**	**0.61**	**-0.03**	**-4.7%**
Infrastructure	**39.06**	**50.12**	**53.70**	**3.58**	**7.1%**

Totals may not add due to rounding.

The National Center for Science and Engineering Statistics (NCSES) was established within the National Science Foundation by Section 505 of the America COMPETES Reauthorization Act of 2010 (P.L. 111-358). The Act provides NCSES with the legislative mission to "…serve as the central federal clearinghouse for the collection, interpretation, analysis, and dissemination of objective data on science, engineering, technology, and research and development." NCSES is called on to support the collection of statistical data on research and development trends, the science and engineering workforce, U.S. competitiveness, and the condition and progress of the Nation's STEM education; to support research using the data it collects and on methodologies in areas related to the work of the Center; and to support the education and training of researchers in the use of its own and other large-scale, nationally representative data sets.

As one of the thirteen principal federal statistical agencies, NCSES has broad responsibility for statistics regarding the science and engineering enterprise. NCSES designs, supports, and directs a coordinated collection of periodic national surveys and performs a variety of other data collections and research, providing policymakers, researchers, and other decision makers with high quality data and analysis on R&D, innovation, the education of scientists and engineers, and the science and engineering workforce. The work of NCSES involves survey development, methodological and quality improvement efforts, data collection, analysis, information compilation, dissemination, web access, and customer service to meet the statistical and analytical needs of a diverse user community. It prepares two congressionally mandated biennial reports — *Science and Engineering Indicators (SEI)* and *Women, Minorities, and Persons with Disabilities in Science and Engineering*. The data collected by NCSES serve as an important resource for researchers in SBE's SciSIP program.

The funding portfolio for NCSES includes ongoing, cyclical surveys; data, reports and other products; and projects accomplished primarily through contracts and grants.

FY 2016 Summary
All funding decreases/increases represent change over the FY 2015 Estimate.

Infrastructure
At the FY 2016 Request, support for NCSES infrastructure activities increases by $3.55 million, to an overall total of $54.31 million. Funding at this level maintains NCSES's core programmatic activities and supports significant targeted improvements in NCSES's statistical and analytic programs.

Additional resources will be used to support (1) development of enhanced data access tools, techniques, and visualizations; ($1.0 million); (2) new data collection techniques building on administrative data and

other "big data" sources ($750,000); and (3) questionnaire redesign and survey improvements supporting current research and policy community needs, such as improved data on pathways for scientists and engineers and measures of innovation ($1.80 million).

SBE OFFICE OF MULTIDISCIPLINARY ACTIVITIES (SMA) — $30,230,000 / +$980,000 / 3.4%

SMA Funding

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, SMA	**$28.14**	**$29.25**	**$30.23**	**$0.98**	**3.4%**
Research	**19.67**	**20.65**	**21.63**	**0.98**	**4.7%**
CAREER	0.03	-	-	-	N/A
Centers Funding (total)	9.23	3.75	-	-3.75	-100.0%
Science of Learning Centers	9.23	3.75	-	-3.75	-100.0%
Education	**6.29**	**5.95**	**5.95**	**-**	**-**
Infrastructure	**2.18**	**2.65**	**2.65**	**-**	**-**
Research Resources	0.73	0.90	0.90	-	-
Research Resources - Public Access Initiative	1.45	1.75	1.75	-	-

Totals may not add due to rounding.

SMA provides a focal point for programmatic activities that cut across SBE and NSF disciplinary boundaries. SMA houses three programs: Science of Science and Innovation Policy (SciSIP), Research Experiences for Undergraduates (REU) Sites, and SBE Postdoctoral Research Fellowships (SPRF). SMA will play a critical role in several NSF areas of emphasis in FY 2016: cyberinfrastructure and computer science (via CIF21); national security (via CNCI); innovation (via I-Corps™); interdisciplinary research and training (via INSPIRE and SBE 2020 activities, such as the IBSS competition and the SPRF-IBSS track); the Science of Learning; and Understanding the Brain (UtB). These investments reflect newly requested funds and a significant redeployment of resources previously committed to other cross-directorate and NSF-wide priority activities. Co-funding with other divisions in SBE and with other directorates is typical for SMA. While all SBE divisions pursue interdisciplinary work, SMA assists with seeding multidisciplinary activities for the future. All areas of SBE sciences are represented in the SMA portfolio.

In general, 43 percent of the total SMA portfolio is available for new research grants and 57 percent is available for continuing grants.

FY 2016 Summary

All funding decreases/increases represent change over the FY 2015 Estimate.

Research

Overall, support increases for basic research activities (+$980,000 to a total of $21.63 million).

- Support for the SLCs terminates (-$3.75 million) as all six of the existing centers will have reached the conclusion of their ten-year funding cycle by the end of FY 2015.
- SMA will increase investment in the Science of Learning (+$2.0 million, for a total of $3.0 million). Funding will support integrative, interdisciplinary research on the Science of Learning and the overarching goal to create, on a national scale, an integrated Science of Learning community.
- Increased support of $2.0 million for UtB (to a total of $6.40 million) will enhance efforts to gain an integrative and comprehensive understanding of the brain and its function in context and in action.

- SMA will continue to invest $1.0 million to support INSPIRE, an NSF priority aligned with SBE 2020.
- Investment in I-Corps™ is maintained at $500,000.
- SMA support for Cyberlearning and Future Learning Technologies is terminated (-$500,000). Funds will be redeployed to support the Science of Learning.
- Funding for the SciSIP disciplinary research activities is held at the FY 2015 Estimate level of $6.10 million.
- With a continued investment of $800,000, SMA will partner with CISE in devoting resources to the SaTC initiative through support for the Cyber Economic Incentives theme within CNCI. This investment will support research at the interstices of the economic and computer sciences to achieve secure practices through market mechanisms and behavioral incentives.
- CIF21 support increases by $190,000, to a total of $1.09 million, for enhanced investments in Data Science Pilots, to address critically important issues related to reproducibility and data access.

Education

Support for education activities in SMA is held at the FY 2015 Estimate of $5.95 million.

- SMA investments in the Research Experiences for Undergraduates (REU) Sites ($2.89 million) and REU supplement ($60,000) programs are continued at the FY 2015 Estimate. Funding will support enhanced research experiences for students in their first two years of college, as recommended by the President's Council of Advisors on Science and Technology (PCAST) in their report, *Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics*[5].
- The SBE Postdoctoral Research Fellowship (SPRF) has two tracks: broadening participation (SPRF-BP), which replaces the former SBE Minority Postdoctoral Fellowships; and interdisciplinary research (SPRF-IBSS) which aligns with SBE 2020 activities. FY 2016 Request funding for these programs is unchanged at $1.50 million for each activity.

Infrastructure

- Continued investment of $1.75 million in NSF's Public Access Initiative will support efforts to make NSF-funded research available to the public, including developing outreach and guidance materials.
- Support for research resources is held constant with the FY 2015 Estimate at $900,000. Funding supports SMA's CIF21 investment inclusive of support for the RIDIR competition, which seeks to develop user-friendly, large-scale, next-generation data resources and relevant analytical techniques to advance fundamental SBE research.

[5] www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-executive-report-final_2-13-12.pdf

OFFICE OF INTERNATIONAL SCIENCE AND ENGINEERING (OISE)

$51,020,000
+$2,500,000 / 5.2%

OISE Funding
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
OISE	**$48.31**	**$48.52**	**$51.02**	**$2.50**	**5.2%**

Totals may not add due to rounding.

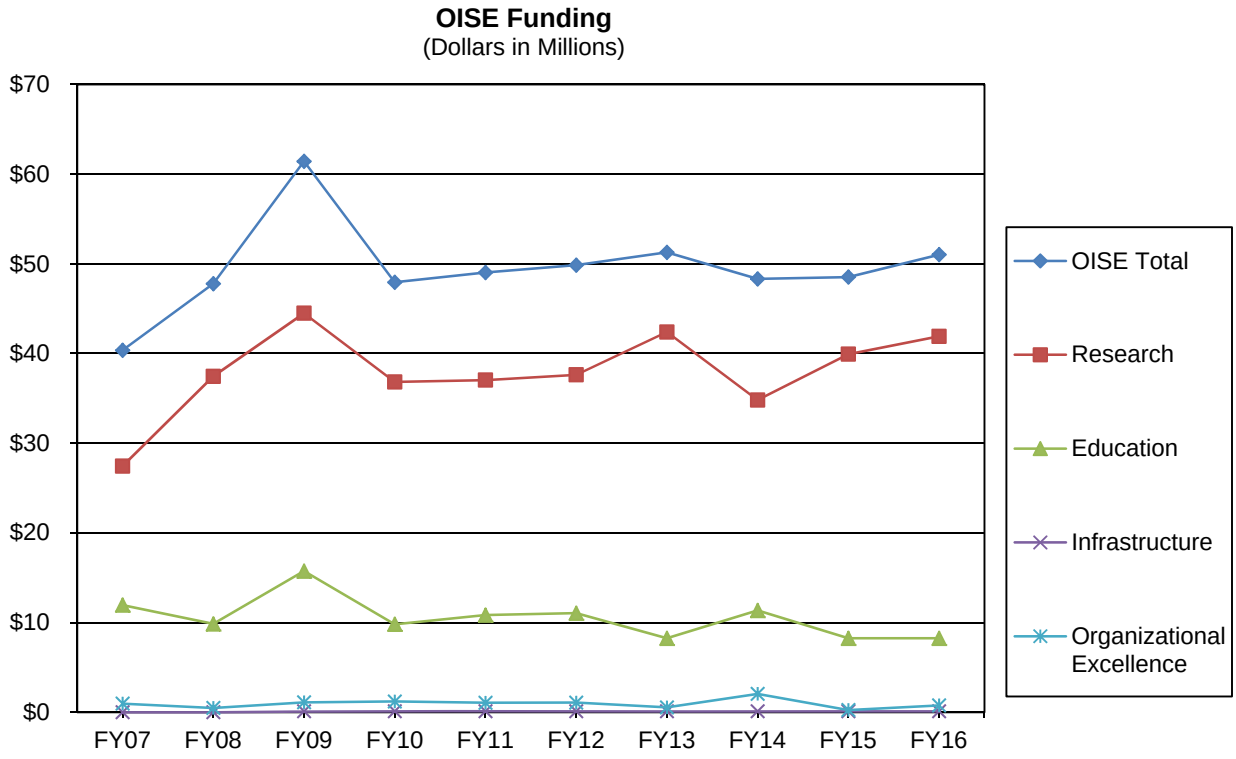
About OISE[1]

The Office of International Science and Engineering (OISE) serves as the NSF focal point for international science and engineering activities. OISE's goal is to promote an integrated, Foundation-wide international strategy and manage internationally-focused programs that are innovative, catalytic, and responsive to a broad range of NSF and national interests. In FY 2016, OISE will emphasize activities that augment and further integrate international engagement of research and education programs across NSF. OISE supports co-funding with NSF directorates and offices through two activities – Science Across Virtual Institutes (SAVI) and the Global Venture Fund (GVF). In addition, OISE manages and funds the Partnerships for International Research and Education (PIRE) program, the International Research Fellowship Program (IRFP), and the International Research Experience for Students (IRES), which support U.S. scientists, engineers, and students engaged in international research and education activities in all NSF-supported disciplines involving any region of the world. OISE's programs and activities are designed to complement and enhance the Foundation's broad research and education portfolio and to overcome barriers to international collaboration. America's next generation of scientists and engineers must be able to work effectively in the global arena and marketplace. OISE supports programs that enable students and researchers to engage in international research and educational activities across such areas as cyberinfrastructure, complex biological systems, natural hazards prediction and mitigation, nanotechnology, water resources, climate, and energy sustainability.

OISE also coordinates much of NSF's engagement with international organizations across diverse disciplines and initiatives. This includes efforts to strengthen collaborations with developing countries – increasingly important partners in addressing critical global issues, but partners which often present special challenges related to infrastructure and resources.

In addition, OISE manages NSF's offices in Beijing, Paris (relocating to Brussels in FY 2015), and Tokyo. These offices report on and analyze in-country and regional science and technology developments and policies, promote greater collaboration between U.S. and foreign researchers, liaise with foreign counterpart agencies and research institutes, and facilitate coordination and implementation of NSF research and education programs.

[1] As part of the 2012 realignment of several offices, OISE was merged into the Office of International and Integrative Activities. Changes within and beyond NSF have now heightened attention across all of NSF to the importance of strong international engagement to fulfilling NSF's mission. The Foundation, through initiatives led by OISE, has sought to infuse international issues into the very fabric of the agency. Realignment of OISE in the Office of the Director in FY 2015 will serve to enhance visibility of NSF's global engagement and strengthen strategic coordination of international activities across the Foundation.



FY 2009 funding reflects both the FY 2009 omnibus appropriation and funding provided through the American Recovery and Reinvestment Act of 2009 (P.L. 111-5).

FY 2016 Summary

OISE Funding
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, OISE	**$48.31**	**$48.52**	**$51.02**	**$2.50**	**5.2%**
Research	36.86	40.17	42.67	2.50	6.2%
Education	11.35	8.25	8.25	-	-
Infrastructure	0.10	0.10	0.10	-	-

Totals may not add due to rounding.

Research

- The FY 2016 Request includes $42.67 million for research, $2.50 million above the FY 2015 Estimate.
- Funding for Science, Engineering, and Education for Sustainability (SEES) is maintained at $10.0 million. This activity aims to lay the foundation for technologies to mitigate and adapt to environmental change that threatens sustainability.

- The FY 2016 Request includes funding to support international collaborations in Clean Energy Technology investments and Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS) (+$1.28 million to a total of $11.28 million). This will enable U.S. researchers to leverage NSF investments with those of other nations, sharing complementary expertise to enhance progress towards meeting global "grand challenges."
- OISE will participate in Understanding the Brain (UtB) (+$500,000 to a total of $500,000) by supporting its international collaborative components, primarily through strategic co-funding.
- The OISE FY 2016 Request will co-fund international disciplinary and interdisciplinary activities largely through the GVF (an approximate increase of $1.21 million). This will continue efforts to involve new funding partners to enable more and stronger research and education collaborations with developing countries. A key example is an NSF-U.S. Agency for International Development (USAID) Memorandum of Understanding that provides a framework under which NSF provides supplementary funding to U.S. investigators to enable collaboration with USAID-supported partners in developing countries. OISE manages NSF's participation in this "Partnerships for Enhanced Engagement in Research" (PEER) program, and in FY 2016 will sustain an investment of approximately $250,000 (usually matched by the cognizant program) for PEER supplements. These funds are further leveraged by approximately $6.0 million in USAID funding.
- Since the inception of the Catalyzing New International Collaborations (CNIC) program in FY 2011, and its predecessor International Planning Visits and Workshops program, OISE has found significant catalytic impacts from international workshops and collaborations at scales larger than individual investigators (e.g., center-to-center collaborations between NSF-funded groups and international counterparts). The program assures focus on priority research areas through coordination with and across divisions, directorates, and (domestic and international) agencies. In order to optimize this impact in FY 2016, approximately $1.50 million (unchanged from FY 2015) will be targeted to such activities, primarily through intra- and inter-agency co-funding. International components of individual collaborations will continue to be supported through co-funding (rather than proliferating small seed proposals).
- OISE will provide approximately $19.0 million of the FY 2016 Request (a decrease of $1.0 million below the FY 2015 Estimate) to support continuing grant increments for the 2012 and 2015 cohorts of PIRE projects. The FY 2015 level reflects the front-loading of one-time expenses (e.g., equipment) in starting the new cohort. This program is heavily leveraged both by other directorates within the Foundation and by international partners.

Education

- OISE supports international research and education activities for U.S. undergraduate and graduate students and post-doctoral fellows via the International Research Experiences for Students (IRES), East Asia and Pacific Summer Institutes for U.S. Graduate Students (EAPSI), and International Research Fellowship Program (IRFP) activities. The total OISE FY 2016 Request for these programs will remain $8.25 million, with additional support available through GVF co-funding.

Infrastructure

- In FY 2016, OISE will continue to provide $100,000 in support of the National Nanotechnology Coordinated Infrastructure (NNCI) to leverage connections and collaborations with foreign institutions. NNCI is the successor to the major multi-user facility, National Nanotechnology Infrastructure Network (NNIN). For information about NNCI, please refer to the Facilities chapter.

Major Investments

OISE Major Investments
(Dollars in Millions)

Area of Investment	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Clean Energy Technology	$13.07	$10.00	$11.28	$1.28	12.8%
INFEWS	-	-	1.28	1.28	N/A
SEES	10.00	10.00	10.00	-	-
Understanding the Brain	-	-	0.50	0.50	N/A

Major investments may have funding overlap and thus should not be summed.

- Clean Energy Technology (+$1.28 million, to a total of $11.28 million): OISE funding will focus on addressing relevant fundamental science drivers in locations and via partnerships around the globe that provide unique insights into associated challenges and opportunities.

- INFEWS (+$1.28 million, to a total of $1.28 million): OISE will co-fund meritorious proposals relevant to INFEWS with international components from across NSF. Targeted opportunities include new, synergistic collaborations that involve early career scientists, engineers, and students. Opportunities in this area are of importance in parts of the developing world, both because of regional needs and potential resources. OISE will work both programmatically and through its non-programmatic facilitation functions on these important efforts. OISE plans to coordinate with other federal agencies (U.S. Department of State, USAID, and U.S. Department of Agriculture) in this area.

- SEES ($10.0 million or equal to the FY 2015 Estimate): OISE will continue to support international components as opportunities arise across the Foundation. It will also serve as a resource to help NSF-supported researchers understand relevant international policies impacting overseas studies.

- Understanding the Brain (+$500,000, to a total of $500,000): NSF's UtB investment has extensive world-wide counterparts, with special foci in the European Union and China. OISE will provide co-funding to UtB programs across the Foundation to assure that U.S. researchers are able to both contribute to and benefit from complementary efforts around the globe. It will also consider relevance to this priority in assessing proposals it manages (e.g., PIRE and CNIC).

Summary and Funding Profile

OISE supports investment in core research and education as well as research infrastructure. A shift in emphasis between small-scale and larger-scale catalytic activities began in FY 2015, resulting in a decrease in the number of proposals and awards, and an increase in the median award size (increases in the average award size and duration reflect primarily the new cohort of 5-year PIRE awards (competitions for which are held on a biennial basis). These trends will continue in FY 2016; the number of research grant proposals is expected to decrease compared to the FY 2015 Estimate (reflecting also the absence of a PIRE competition in 2016). Average annualized award size and duration are estimated to decrease in FY 2016 due to the absence of a PIRE competition.

OISE Funding Profile

	FY 2014 Actual Estimate	FY 2015 Estimate	FY 2016 Estimate
Statistics for Competitive Awards:			
Number of Proposals	679	630	650
Number of New Awards	308	270	260
Funding Rate	45%	43%	40%
Statistics for Research Grants:			
Number of Research Grant Proposals	454	390	250
Number of Research Grants	83	70	45
Funding Rate	18%	18%	18%
Median Annualized Award Size	$60,266	$83,000	$80,000
Average Annualized Award Size	$98,812	$280,000	$100,000
Average Award Duration, in years	1.7	2.0	1.7

Program Monitoring and Evaluation

External Program Evaluations and Studies:

- An evaluation of the Foundation-wide International Research Fellowship program (managed by OISE) was performed during FY 2012 to investigate the international experiences and the research, educational, and employment outcomes of FY 1992-FY 2010 fellowship awardees.[2] The report was delivered to OISE in FY 2013. The evaluation found that fellows made important and enduring connections with researchers in their host country and that their subsequent collaborations with researchers in foreign countries were more productive than those of their peers. IRFP awardees were as productive in research as their peers, were as likely to hold a faculty rank of assistant, associate, or full professor, and were as likely to be tenured. The evaluation found the program to be effective and recommended continuation. In FY 2015, the NSF-wide Fellowship Coordinating Committee began an internal assessment of the optimum structure for advancing the interests of the program; implementation is expected in FY 2016.
- An evaluation of the first 59 Partnerships for International Research and Education funded since inception in 2005 is currently being conducted. A comparison group is being selected from projects funded by programs for which international collaboration was not required (but may have been encouraged), using criteria such as award amount, duration, type of grant, year funded, and disciplinary focus. Principal investigators (PIs), co-PIs, postdoctoral and graduate student participants from each PIRE project and the matched comparison projects will be surveyed. The report is expected in December 2015.

Science and Technology Policy Institute (STPI) Report:

- In FY 2013, OISE initiated a STPI study to assess the effectiveness of the NSF overseas offices. A preliminary report was received in February 2014. The draft was generally supportive of the mission and value offered by all three offices. Final results from this study are expected during FY 2015. The preliminary report is guiding planning for the offices, including a move of the Europe office to Brussels, and enhancement of IT capabilities at all offices.

[2] http://abtassociates.com/AbtAssociates/files/58/581035b4-c55a-40b9-bd09-98b23cb59321.pdf

Committee of Visitors (COV):

- The International Science and Engineering (ISE) Section of the Office of International and Integrative Activities (OIIA) held a triennial Committee of Visitors (COV) meeting on September 16-17, 2014. The resulting report, which was accepted by the Advisory Committee on International Science and Engineering (AC-ISE) at their November 6 virtual meeting, is posted along with the Office's response.[3]

Since the report was accepted by the AC-ISE, significant progress has been made towards responding to the recommendations.

The Performance chapter provides details regarding the periodic reviews of programs and portfolios of programs by external Committees of Visitors and directorate/office Advisory Committees. Please see this chapter for additional information.

Number of People Involved in OISE Activities

	FY 2014 Actual Estimate	FY 2015 Estimate	FY 2016 Estimate
Senior Researchers	504	510	540
Other Professionals	67	70	70
Postdoctorates	54	50	50
Graduate Students	145	150	160
Undergraduate Students	100	100	110
Total Number of People	**870**	**880**	**930**

[3] www.nsf.gov/od/iia/activities/cov/covs.jsp#oia

INTEGRATIVE ACTIVITIES (IA) $459,150,000
+$33,810,000 / 7.9%

IA Funding
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Percent
Career-Life Balance	$1.50	-	-	-	N/A
EPSCoR	158.19	159.69	169.99	10.30	6.4%
Graduate Research Fellowships	150.00	166.72	168.75	2.03	1.2%
INSPIRE	24.92	13.75	13.75	-	-
Major Research Instrumentation	89.59	75.00	75.00	-	-
NSF INCLUDES	-	-	1.88	1.88	N/A
Research Investment Communications (RIC)	1.80	3.14	3.14	-	-
Science & Technology Centers Class of 2016	-	-	20.00	20.00	N/A
Science & Technology Centers Administration	0.84	1.30	0.90	-0.40	-30.8%
Science & Technology Policy Institute	4.89	4.74	4.74	-	-
STAR METRICS	1.40	1.00	1.00	-	-
Total, IA	**$433.12**	**$425.34**	**$459.15**	**$33.81**	**7.9%**

Totals may not add due to rounding.

About IA

The FY 2016 Request for IA is driven by six aspects of the mission of the Foundation: catalyzing new concepts and fields across all disciplinary boundaries; promoting efforts to strengthen research and education in science and engineering throughout the United States and to avoid undue concentration of research and education; expanding critical human capital infrastructure; leveraging physical resources across disciplines to seed a knowledge-based economy; and evaluating the impacts of NSF's investments to make more data-driven decisions, and to establish a culture of evidence-based planning and policy-making.

IA's FY 2016 Request will provide support in frontier research areas, including clean energy and Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS). The Office of Integrative Activities (OIA) will co-lead new activities in broadening participation (BP), which support the Administration's diversity agenda.

FY 2016 Summary

All funding changes are over FY 2015 Estimate.

- The Experimental Program to Stimulate Competitive Research (EPSCoR) (+$10.30 million to a total of $169.99 million) funding in FY 2016 will catalyze key research themes, including national research priorities, and other activities within and among EPSCoR jurisdictions that empower knowledge generation and broaden participation in science and engineering. Additionally, EPSCoR themes will draw upon the findings of the National Academy of Sciences (NAS) study of EPSCoR[1]

[1] www.nap.edu/catalog.php?record_id=18384

and EPSCoR-like programs as called for in the America COMPETES Reauthorization Act of 2010 (P.L. 111-358).

- The Graduate Research Fellowship (GRF) program invests (+$2.03 million to a total of $168.75 million) in the U.S. science and engineering human capital necessary to ensure the Nation's leadership in STEM research and innovation through the selection and support of outstanding U.S. graduate students. IA provides 50 percent of NSF's funding for GRF, with the remainder provided through the Education and Human Resources account. For additional information on GRF, please see the discussion of graduate education in the NSF-Wide Investments section.

- In FY 2016, Integrated NSF Support Promoting Interdisciplinary Research and Education (INSPIRE) (no change for a total of $13.75 million) will continue to spur new interdisciplinary and potentially transformative scientific and engineering concepts and fields. INSPIRE is an NSF-wide investment that addresses the complicated and pressing scientific problems at the intersection of traditional disciplines. In FY 2016, IA funding will allow for approximately 30 up-to-$1.0-million INSPIRE awards; with an equal amount being provided by other NSF directorates. The IA co-funding serves as an incentive to engage in cross-cutting collaboration and risk-taking on potentially transformative research.

- Major Research Instrumentation (MRI) program (no change for a total of $75.0 million) will continue to catalyze new knowledge and discoveries by empowering the Nation's scientists and engineers with state-of-the-art research instrumentation. The MRI program supports the acquisition and development of instruments such as: advanced imaging systems for biological, chemical and materials research; new types of detectors for telescopes and high-energy physics experiments; next-generation genome sequencers; magnetic resonance imagers for neuroscience; and cyberinfrastructure. MRI investments support research-intensive learning environments that promote the development of a diverse workforce trained in the use of state-of-the-art instrumentation in research, and facilitate academic/private sector partnerships. The FY 2016 funding level will support roughly 160 MRI awards, or equal to the number anticipated in FY 2015.

- Inclusion across the Nation of Communities of Learners that have been Underrepresented for Diversity in Engineering and Science (NSF INCLUDES) is a campaign and associated set of investments to broaden knowledge of and participation in STEM fields. This initiative invests in community-generated bold visions that represent new models and new partnerships and will serve as national resources to increase the preparation, participation, advancement, and contributions of those who have been traditionally underserved and/or underrepresented in the science, technology, engineering, and mathematics (STEM) enterprise: women/girls, underrepresented ethnic/racial groups, and persons with disabilities. In FY 2016, $1.88 million will fund the Networks for STEM Excellence pilot. For additional information on NSF INCLUDES, please see the NSF-Wide Investments section.

- Research Investment Communications (RIC) funding in FY 2016 is $3.14 million, or equal to the FY 2015 Estimate. RIC is a leading-edge communications effort intended to increase awareness and support of science and engineering. RIC makes NSF's investments in science, technology, engineering, and mathematics readily available and easily understandable. RIC supports events that highlight NSF partnerships such as the USA Science and Engineering Festival. In FY 2016, RIC will focus on informing policy makers, the media, and the general public on the impact of these investments on our daily lives and the Nation's future.

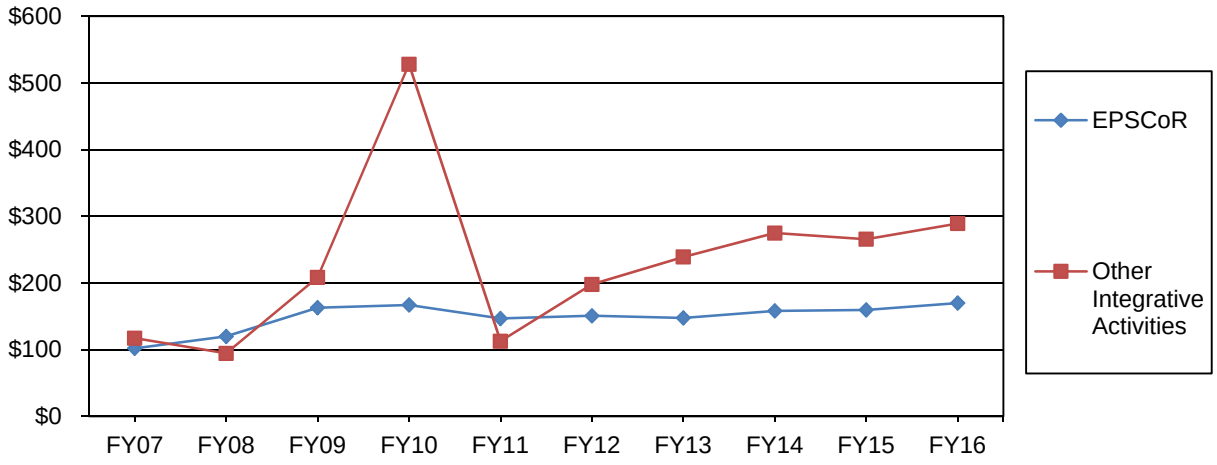
- Science and Technology Centers: Integrative Partnerships (STC) program supports innovative,

potentially transformative, complex research and education projects that require large-scale, long-term awards. STCs engage the Nation's intellectual talent through partnerships across academia, industry, national laboratories, and government. These collaborations create synergies that enhance the training of the next generation of scientists, engineers, and educators. STCs have impressive records of research achievements as well as strong partnerships with education communities and industry. A new solicitation was announced in FY 2014 that replaces the sunsetting Class of 2005 and 2006 cohort of STCs and encourages themes consistent with NSF priorities. The FY 2016 Request of $20.0 million will support up to four new STCs. Additionally, $900,000 will support the administrative costs associated with the STC post award management for the existing eight centers.

- The Science and Technology Policy Institute (STPI) (no change for a total of $4.74 million). STPI is a Federally Funded Research and Development Center sponsored by NSF on behalf of the White House Office of Science and Technology Policy (OSTP). STPI provides analysis of significant domestic and international science and technology policies and developments for OSTP and other federal agencies.

- Science and Technology for America's Reinvestment: Measuring the Effect of Research on Innovation, Competitiveness, and Science (STAR METRICS) (no change for a total of $1.0 million) is an interagency pilot activity that represents a transformative approach to developing information on how NSF and other federal research and development investments affect the innovation ecosystem. Funding will enable NSF to meet commitments to the interagency STAR METRICS partnership, promote the integration of elements of STAR METRICS to developing assessment and evaluation information system linked to NSF's management information systems, and support assessment and evaluation pilots in NSF programs using STAR METRICS tools. The project supports the assessment and evaluation plans described in *Investing in Science, Engineering, and Education for the Nation's Future – NSF Strategic Plan 2014 – 2018*.

IA Subactivity Funding
(Dollars in Millions)



FY 2009 funding reflects both the FY 2009 omnibus appropriation and funding provided through the American Recovery and Reinvestment Act of 2009 (P.L. 111-5).

Program Monitoring and Evaluation

External Program Evaluations and Studies:

- In FY 2015, IA will co-fund with the Directorate for Engineering an evaluation of the NSF Innovation Corps (I-Corps™) program based on the FY 2014 feasibility study. A longitudinal data collection and formal evaluation study will be launched to evaluate the impact of the I-Corps™ program. Results are expected to be used to inform programmatic directions. Final results from this study are expected in FY 2016.
- There are three evaluations underway, each of which is summarized below:
  - The INSPIRE program is currently being assessed. The external formative assessment will test whether the process is conducive to achieve program and portfolio-level goals. Final results from this study are expected in FY 2016.
  - The NSF merit review process is currently being assessed. The scope of the study is to enable an assessment of changes in workload, the impacts of the technologies used to support merit review, and the quality of feedback provided to principal investigators. The evaluation is being conducted by INSIGHT. Final results from this study are expected in FY 2016.
  - The Career Life Balance initiative is being assessed from inception in 2011 to current implementation in 2014. The formative evaluation will be used to: document objectively progress to date; inform strategic planning for priority setting; and make improvements in management of the initiative. Final results from this study are expected in FY 2016.
- Final actionable reports from the Science, Engineering, and Education for Sustainability (SEES) evaluations will be received in the Summer of FY 2015.
- The America COMPETES Reauthorization Act of 2010 (H.R. 5116, Sec. 517) stated that "the Director [NSF] shall contract with the National Academy of Sciences to conduct a study on all Federal agencies that administer an Experimental Program to Stimulate Competitive Research or a program similar to the Experimental Program to Stimulate Competitive Research [EPSCoR]." An evaluation of EPSCoR and EPSCoR-like programs (Government-wide) was performed by the National Academy of Science (NAS) to investigate: (1) the delineation of policies of each Federal agency with respect to awarding of grants to EPSCoR States; (2) the effectiveness of each program; (3) improvements for each agency to achieve EPSCoR goals; (4) the effectiveness of EPSCoR States in using awards to develop science and engineering research and education infrastructure within their States; and (5) the overall effectiveness of EPSCoR.
  - The NAS report presented several high-level findings based on the committee's assessment.[2]
  - NSF will respond to those recommendations and take appropriate actions as informed by such reports in FY 2015.

Science and Technology Policy Institute (STPI) Reports:

- An evaluation of the NSF EPSCoR program was performed by STPI to investigate: (1) progress over time in the percentage of NSF funding received by EPSCoR jurisdictions; (2) the difference over time between individual investigators in EPSCoR and non-EPSCoR jurisdictions with respect to factors such as proposals per faculty member and proposal success rates; and (3) time series analyses of the evolution of NSF funding in EPSCoR and non-EPSCoR jurisdictions. The STPI report included several high-level findings based on STPI's assessment of NSF's EPSCoR program.[3]

Workshops and Reports:

- Broader Impacts Infrastructure Summit and a recently released report on Perspectives on Broader Impacts have been of interest to the STEM community.[4] The America COMPETES Reauthorization

[2] www.nap.edu/catalog.php?record_id=18384
[3] www.ida.org/~/media/Corporate/Files/Publications/STPIPubs/2015/P-5221.ashx
[4] www.nsf.gov/od/iia/publications/Broader_Impacts.pdf

Act of 2010 (P.L. 111-358, Sec 526) reaffirmed the importance of the broader impacts criterion and encouraged institutions of higher education and nonprofit organizations to take an institutional approach towards achieving the societal benefits championed via broader impacts. This institutional approach has been embraced by a number of institutions of higher education and nonprofits, who are collectively pooling their expertise and experiences to put in place on their campuses the broader impacts infrastructure that is necessary. The Broader Impacts Infrastructure Summit, held in Arlington, VA, in April 2014, brought together more than 120 professionals from 80 higher education institutions and nonprofits for wide-ranging discussions on broader impacts focused on institutional collaboration, guidance, and accountability.

Committees of Visitors (COV):

- In 2015, COVs will review the Experimental Program to Stimulate Competitive Research.
- In 2016, COVs will review the Science and Technology Centers program.

The Performance chapter provides details regarding the periodic reviews of programs and portfolios of programs by external Committees of Visitors and directorate and office Advisory Committees. Please see this chapter for additional information.

EXPERIMENTAL PROGRAM TO STIMULATE COMPETITIVE RESEARCH (EPSCoR) — $169,990,000 / +$10,300,000 / 6.4%

EPSCoR Funding
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, EPSCoR	**$158.19**	**$159.69**	**$169.99**	**$10.30**	**6.4%**
Research Infrastructure Improvement (RII)	131.90	121.58	128.99	7.41	6.1%
Co-Funding	25.32	36.11	39.00	2.89	8.0%
Outreach and Workshops	0.97	2.00	2.00	-	-

Totals may not add due to rounding.

EPSCoR assists the National Science Foundation (NSF) in its statutory function "to strengthen research and education in science and engineering throughout the United States and to avoid undue concentration of such research and education." EPSCoR goals are: 1) to provide strategic programs and opportunities for EPSCoR participants that stimulate sustainable improvements in their R&D capacity competitiveness; and 2) to advance science and engineering capabilities in EPSCoR jurisdictions for discovery, innovation and overall knowledge-based prosperity.

EPSCoR's FY 2016 Request uses three strategic investment tools: Research Infrastructure Improvement (RII) awards, co-funding, and outreach and workshops.

FY 2016 Summary

All funding increases represent change over the FY 2015 Estimate.

Research Infrastructure Improvement (RII)

- RII (+$7.41 million to a total of $128.99 million): RII awards support development of physical, human, and cyber-based research infrastructure in EPSCoR jurisdictions with emphasis on collaborations among academic researchers, the private sector, and state and local governments to effect sustainable improvements in research infrastructure. These awards are designed to improve the research competitiveness of jurisdictions by strengthening their academic research infrastructure in areas of science and engineering supported by NSF and critical to the particular jurisdiction's science and technology initiative or plan. RII awards also increase the participation of underrepresented groups in STEM and enable broader regional and topical collaborations among jurisdictions and facilitate the enhancement of discovery, learning, and economic development of EPSCoR jurisdictions.

Co-Funding

- Co-funding (+$2.89 million to a total of $39.0 million): EPSCoR co-invests with NSF directorates and offices on meritorious proposals from individual investigators, groups, and centers in EPSCoR jurisdictions that are submitted to the Foundation's research and education programs, and to crosscutting initiatives. These proposals are merit reviewed in NSF disciplinary programs and recommended for award, but cannot be funded without the combined, leveraged support of EPSCoR. Through this funding mechanism, EPSCoR will support INFEWS ($5.0 million) and Clean Energy Technology ($10.77 million). Furthermore, other NSF priority areas like Understanding the Brain may be supported by EPSCoR co-funding activities.

Outreach and Workshops

- The Outreach and Workshops (unchanged to a total of $2.0 million) component of EPSCoR solicits requests for support of workshops, conferences, and other community-based activities designed to explore opportunities in emerging areas of science and engineering, and to share best practices in strategic planning, diversity, communication, cyberinfrastructure, evaluation, and other capacity-building areas of importance to EPSCoR jurisdictions. EPSCoR also supports outreach travel that enables NSF staff from all directorates and offices to directly engage and inform the EPSCoR research community about NSF opportunities, priorities, programs, and policies.

Number of People Involved in EPSCoR Activities

	FY 2014 Actual Estimate	FY 2015 Estimate	FY 2016 Estimate
Senior Researchers	531	500	600
Other Professionals	242	200	300
Postdoctorates	71	70	70
Graduate Students	443	500	500
Undergraduate Students	571	600	600
K-12 Teachers	3,945	4,000	4,200
K-12 Students	70,415	71,100	75,700
Total Number of People	**76,218**	**76,970**	**81,970**

UNITED STATES ARCTIC RESEARCH COMMISSION (USARC)

$1,480,000
+$70,000 / 5.0%

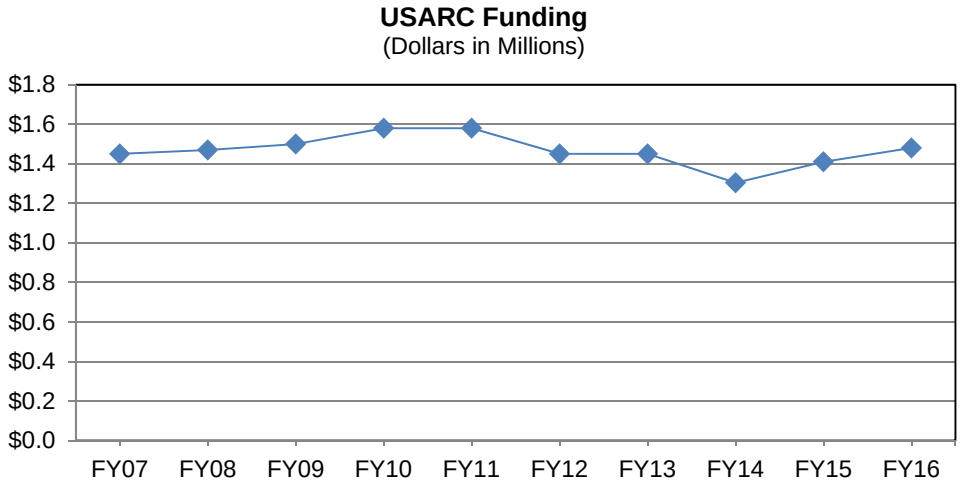
USARC Funding
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
USARC	**$1.30**	**$1.41**	**$1.48**	**$0.07**	**5.0%**

About USARC

USARC was created by the Arctic Research and Policy Act of 1984, (as amended, P. L. 101-609), to assist in establishing the national policy, priorities, and goals necessary to construct a federal program plan for basic and applied scientific research with respect to the Arctic. This request provides funds to advance Arctic research, to recommend Arctic research policy, and to communicate research and policy recommendations. In addition, USARC advises the Interagency Arctic Research Policy Committee (IARPC) in developing national Arctic research projects and a five-year plan to implement those projects. USARC also supports interaction with Arctic residents, international Arctic research programs and organizations, and local institutions, including regional governments, in order to obtain the broadest possible view of Arctic research needs. USARC is an independent federal agency, funded through NSF's appropriation, specifically as an activity in the Research and Related Activities account.

The USARC is requesting $1.48 million, an increase of $70,000 above the FY 2015 Estimate level. The FY 2016 Request will support three FTE funded at USARC. In addition, the FY 2016 Request supports one full-time contractor and four part-time contractors. A total of seven compensated personnel are authorized per P.L. 101-609. The seven Commissioners may also receive up to 90 days of salary per year, at the Executive Schedule Level IV.



EDUCATION AND HUMAN RESOURCES (EHR) $962,570,000
+$96,570,000 / 11.2%

EHR Funding

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Division of Research on Learning in Formal and Informal Settings (DRL)	$230.13	$221.52	$253.08	$31.56	14.2%
Division of Graduate Education (DGE)	245.58	273.41	295.64	22.23	8.1%
Division of Human Resource Development (HRD)	139.21	143.73	145.59	1.86	1.3%
Division of Undergraduate Education (DUE)	217.10	227.34	268.26	40.92	18.0%
Total, EHR	**$832.02**	**$866.00**	**$962.57**	**$96.57**	**11.2%**

Totals may not add due to rounding.

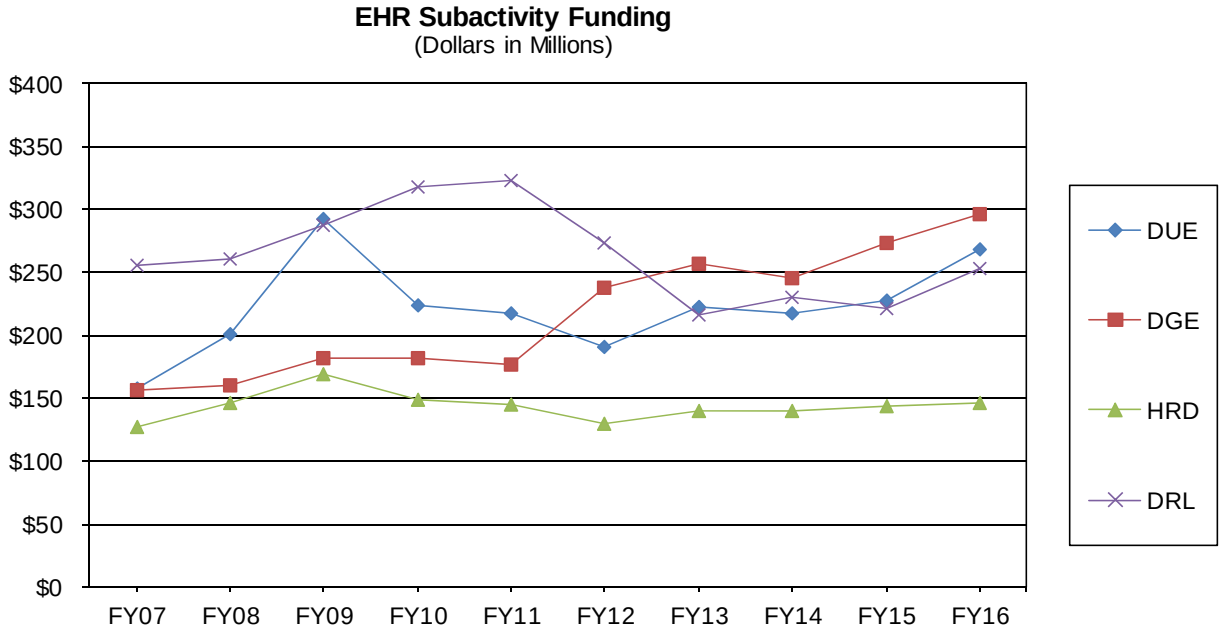
About EHR

The vision of a healthy and vital U.S. science, technology, engineering, and mathematics (STEM) enterprise inspires the investments of the National Science Foundation's (NSF) Directorate for Education and Human Resources (EHR). The directorate's mission is to provide the research foundation to develop a diverse, STEM literate public and workforce ready to advance the frontiers of science and engineering for society. For more than 60 years NSF has invested in bold programs, innovative projects, and rigorous research in STEM education. This FY 2016 budget builds on those investments with a growing emphasis on "core" STEM education research to better engage, sustain, and retain STEM learners, leading to an inclusive and competitive STEM workforce. It includes plans to catalyze exciting and important work in new modes of learning and teaching in the context of rapidly changing U.S. demographics, diverse learner populations, rapid technology growth, and unprecedented science-based educational opportunities. EHR investments provide a foundation for addressing both enduring and emerging challenges in STEM education. EHR-funded projects are leading to STEM success including breakthroughs in technology-enabled learning, learning in informal environments, and in reaching all learners at all levels, including those who have been underrepresented in STEM. NSF-funded research has: proven the benefits of active-learning approaches to retaining more undergraduates in STEM;[1] shown the critical importance of mathematics and science learning for pre-school children,[2] and demonstrated that systemic efforts to improve mathematics learning can result in collective community impact for underrepresented students.[3] EHR advances federal investments in STEM education by funding the research and development that informs strategic education investments across NSF and other agencies.

[1] Freeman S, et al. (2014) Active learning increases student performance in science, engineering, and mathematics. Proc Natl Acad Sci USA 111(23):8410–8415.

[2] National Research Council (2009) Mathematics Learning in Early Childhood: Paths Toward Excellence and Equity. Washington DC: National Academy Press.

[3] Hill, O., Serpell, Z. & Faison, M. (2012) Improving minority student mathematics performance through cognitive training. In L.A. Flowers, J. Moore, and L. O. Flowers (Eds.), The Evolution of Learning: Science, Technology, Engineering, and Mathematics Education at Historically Black Colleges and Universities, University Press of America.



FY 2009 funding reflects both the FY 2009 omnibus appropriation and funding provided through the American Recovery and Reinvestment Act of 2009 (P.L. 111-5).

Appropriations Language

For necessary expenses in carrying out science, mathematics and engineering education and human resources programs and activities pursuant to the National Science Foundation Act of 1950 (42 U.S.C. 1861 et seq.), including services as authorized by section 3109 of title 5, United States Code, authorized travel, and rental of conference rooms in the District of Columbia, ~~$866,000,000,~~*$962,570,000*, to remain available until September 30, ~~2016. *Provided*, That not less than $60,890,000 shall be available for activities authorized by section 7030 of Public Law 110-69.~~*2017*.

Education and Human Resources
FY 2016 Summary Statement
(Dollars in Millions)

	Enacted/ Request	Unobligated Balance Available Start of Year	Unobligated Balance Available End of Year	Adjustments to Prior Year Accounts	Transfers	Obligations/ Estimates
FY 2014 Appropriation	$846.50	$2.18	-$16.37	$0.77	-$1.06	$832.02
FY 2015 Estimate	866.00	16.37				882.37
FY 2016 Request	962.57					962.57
$ Change from FY 2015 Estimate						$80.20
% Change from FY 2015 Estimate						9.1%

Totals may not add due to rounding.

Explanation of Carryover

Within the **Education and Human Resources (EHR)** account, $16.37 million (including $281,000 in reimbursable funds) was carried over into FY 2015. It is estimated that these funds will be obligated during the second quarter of FY 2015.

- $12.50 million for the NSF Research Traineeship (NRT) was carried over. The solicitation for the cross-directorate program was released on March 24, 2014, with 258 proposals received by the June 24, 2014 due date. Thirteen panels were scheduled during the August 18 to September 15 timeframe. Award recommendations will be finalized during the second quarter of FY 2015.

- $2.75 million for the Excellence Awards in Science and Engineering (EASE) Program:
  - $2.36 million for the Presidential Awards for Excellence in Mathematics and Science Teaching (PAEMST) program was carried over into FY 2015. The FY 2013 awardees were not recognized in FY 2014 and have been scheduled to be recognized in FY 2015 along with the FY 2014 awardees.
  - $394,000 for the Presidential Awards for Excellence in Science, Mathematics and Engineering Mentoring (PAESMEM) was carried over into FY 2015. The FY 2012 and FY 2013 awardees were not recognized in FY 2014. They are scheduled to be recognized in FY 2015 along with FY 2014 awardees.

- $827,693 for the Robert Noyce program was carried over into FY 2015 for awards that were not ready for obligation.

- Within EHR, $281,000 of incoming two-year interagency funds were carried over.

FY 2016 EHR Summary

The EHR budget request is framed by the three thematic areas that have guided the directorate's investments in recent years and that have been further developed by the EHR Advisory Committee in its report, *Strategic Re-Envisioning for the Education and Human Resources Directorate*.[4] The themes are: 1) STEM learning and learning environments, 2) broadening participation and institutional capacity in STEM, and 3) the preparation of those who will pursue a wide range of STEM careers. The request reflects NSF's commitment to growing the research base that will guide and inform more rapid and meaningful change in STEM learning and STEM education.

In FY 2016, continuing and expanding investments in the EHR Core Research (ECR) program remains a top priority. EHR's research and development focus for FY 2016, through the ECR program as well as other more targeted programs, will emphasize several key areas.

- Within the **learning and learning environments** theme: early childhood STEM learning; advances in cyberlearning and the study of complex privacy issues related to learning data; translation of the science of learning into educational environments; learning issues in specific STEM disciplines, with emphasis in mathematics because of national needs; and learning opportunities within rich science contexts such as research centers, major facilities, and large instruments.

- Within the **broadening participation and institutional capacity** theme: understanding changing demographics and using diversity as an asset for science; new roles for informal learning environments to engage learners from groups traditionally underrepresented in STEM; strategic

[4] www.nsf.gov/ehr/Pubs/AC_ReEnvisioning_Report_Sept_2014_01.pdf

impact in the K-12 levels for broadening participation; and "bold visions" for strategic focus, as part of the NSF Inclusion across the Nation of Communities of Learners that have been Underrepresented for Diversity in Engineering and Science (NSF INCLUDES) priority.

- In the area of development of the **STEM professional workforce** theme: tomorrow's teachers and educators; new STEM literacies (e.g., data literacy, coding literacy, and "making" literacy); and preparing graduate students broadly for STEM careers and in emerging areas such as data science.

These themes will guide a coherent suite of NSF-wide investments in undergraduate education, coordinated through EHR. The investments collectively are designed to improve access and transition to high-quality undergraduate STEM learning opportunities for all of the Nation's students, and to transform undergraduate learning opportunities so that students are attracted to and able to succeed in STEM studies. In FY 2016, EHR will promote the study and scaling of such evidence-based practices as active learning approaches and research-based courses.

Two EHR-wide emphases in FY 2016 will be: 1) ensuring that promising practices, key findings, and accumulated knowledge are used and adapted for influence on STEM education "at scale"; and 2) on growing partnerships across the agency and externally to support education research-based strategies for preparing tomorrow's diverse communities of scientists, engineers, and other STEM career professionals to lead the world in innovation and frontier research.

EHR's commitment to collaborations across NSF in efforts to shape a highly competent STEM workforce is reflected in the alignment of the innovation component of the NSF Research Traineeship (NRT) program with the FY 2016 NSF-wide priorities Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS) and Understanding the Brain (UtB). EHR solicitations and calls for proposals for NRT will challenge the field to devise cutting-edge innovations in preparing graduate students to be researchers in these evolving areas. EHR will further participate, through other ongoing EHR programs, in the agency-wide INFEWS priority with an emphasis on learners' engagement to help understand what is needed to create a highly skilled and diverse science and engineering workforce to address the food-energy-water nexus, and to support the development of new evidence-based instructional approaches for interdisciplinary courses that address this nexus. EHR also participates in Cyberinfrastructure Framework for 21st Century Science, Engineering, and Education (CIF21) and in Secure and Trustworthy Cyberspace (SaTC) through the CyberCorps®: Scholarship for Service (SFS) program. NSF-wide commitment is also evident in EHR's continued leadership in Improving Undergraduate STEM Education (IUSE) and in the Cyberlearning and Future Learning Technologies program, in partnership with the Directorate for Computer and Information Science and Engineering (CISE).

Broadening participation is a Foundation-wide priority, and in FY 2016 NSF plans to launch a new program, NSF INCLUDES. EHR will partner with the Office of Integrative Activities (OIA) to co-lead this effort. EHR will encourage principal investigators (PIs) from the five largest NSF focused programs in broadening participation (ADVANCE, Centers of Research Excellence in Science & Technology (CREST), Louis Stokes Alliances for Minority Participation (LSAMP), Historically Black Colleges and Universities Undergraduate Program (HBCU-UP), and the Tribal Colleges and Universities Program (TCUP)) to be leaders and innovators in developing a focused set of "bold visions" for inclusion that will provide rallying points for the program. This will aid in the creation of two pilot activities NSF INCLUDES: Networks for STEM Excellence (led by OIA) and NSF INCLUDES: Empowering All Youth for STEM (led by EHR). For more detailed information on NSF INCLUDES, see the NSF-Wide Investments chapter.

Another major emphasis for EHR in FY 2016, through current programs, will be a focus on the translation, adaptation, and wide use/uptake of findings, models, and tools supported by EHR awards.

One key approach will be the expansion of I-Corps™ for Learning. This budget request proposes increased emphasis within EHR programs on designing for scale and on implementation science. EHR also will continue to catalyze the research community to move education from a data-poor to a data-rich endeavor through investment in data science pilots and related efforts. Finally, consistent with the advice of the EHR Advisory Committee, EHR will build mechanisms using traditional and technological approaches to synthesize and summarize the findings and results of EHR-funded research and development into forms that are useful to a variety of audiences.

EHR will continue to provide leadership to the cross-agency Federal Coordination in STEM Education (FC-STEM) Task Force in the implementation of the Federal STEM Education 5-Year Strategic Plan developed by the Committee on STEM Education (CoSTEM). EHR staff will serve as working group leaders and members and will provide leadership in developing the evidence base for effective STEM education at all levels in both formal and informal settings, with the long-term outcome to be greater impact and efficiency for the federal investment in STEM education.

FY 2016 Summary by Division

- The Division of Research on Learning in Formal and Informal Settings (DRL) invests in fundamental research on STEM learning. This includes the development and testing of innovative resources, models, and tools for STEM learning both inside and outside of school, for the public, for preK-12 students, for teachers, and for youth; research on national STEM education priorities; and evaluation studies and activities. The FY 2016 DRL investment for ECR: STEM Learning increases $23.64 million over the FY 2015 Estimate to a total of $49.27 million, allowing support for a wider range of high quality foundational studies across the STEM domains and across levels and institutional type. The Discovery Research K-12 (DRK-12) program increases $8.12 million over the FY 2015 Estimate to a total of $91.93 million to support awards that focus on research and development models and tools for preK-12 education. The Advancing Informal STEM Learning (AISL) program increases by $5.0 million to $60.0 million, allowing expanded emphasis on broadening participation through informal learning environments.

- The Division of Graduate Education (DGE) provides support to U.S. graduate students and innovative graduate programs to prepare tomorrow's leaders in STEM. DGE's role includes support for research that focuses on the general issues related to the development of the STEM professional workforce at the graduate level. In FY 2016, ECR: STEM Professional Workforce Preparation, led by DGE, will increase $4.12 million to a total of $20.09 million. DGE will increase its interactions with STEM workforce preparation programs based in other EHR divisions in areas such as teacher preparation and professional development and STEM career development at the undergraduate level. DGE provides intellectual leadership for the use and conduct of research that provides the knowledge base that informs implementation of successful approaches, practices, and models for STEM professional workforce preparation. Another focus for DGE in FY 2016 is reflected in the plan to align NRT with the NSF-wide scientific priorities INFEWS and UtB. At the same time, DGE will continue to promote innovation in graduate education through activities that provide new professional development opportunities for Graduate Research Fellowship (GRF) fellows (i.e., Graduate Research Opportunities Worldwide (GROW) and Graduate Research Internships Program (GRIP)) and through research on the implementation of innovative new program and learning opportunities.

  DGE has the administrative and intellectual responsibility for the development and implementation of the NSF Strategic Plan in Graduate Education (particularly in areas of human capital) and co-leads with the National Institutes of Health (NIH) the FC-STEM Interagency Working Group on Graduate Education to advance cooperation and collaboration of graduate education with other federal

agencies. DGE is the home and lead division for EHR's Program and Project Evaluation (PPE) program, and plays a leading role in the oversight of the EHR evaluation portfolio.

- The Division of Human Resources Development (HRD) invests in building a diverse and well-qualified STEM workforce through broadening the participation of groups underrepresented in STEM. In FY 2016, HRD continues leading efforts to improve STEM education for Hispanic students by focusing on Hispanic-serving two-year institutions in partnership with a variety of programs throughout EHR. HRD investments in HBCUs, Tribal Colleges and Universities (TCUs), and other minority-serving institutions remain critically important. These programs together with ADVANCE, CREST, and LSAMP will be instrumental in encouraging its PI community in leading the development of a set of "bold visions" for inclusions. LSAMP will work with DRL's AISL program to ensure that the pilot activities for the NSF INCLUDES: Empowering All Youth for STEM priority will support innovative and bold ideas in broadening participation. HRD also leads the ECR: Broadening Participation and Institutional Capacity in STEM activity, which increases by $1.86 million over the FY 2015 Estimate to a total of $14.74 million to allow for additional research to build the science of broadening participation.

- The Division of Undergraduate Education (DUE) provides NSF-wide leadership and expertise for transforming undergraduate STEM education to anticipate the needs of the 21st century STEM workforce. This includes an emphasis on: evidence-based and evidence-generating approaches to improve undergraduate education; discipline-focused needs in learning research and development of physical virtual tools, technologies, and other learning experiences; and focus on emerging areas of science that warrant inclusion in undergraduate programs in STEM. In FY 2016, led by DUE, ECR: STEM Learning Environments increases $3.64 million over the FY 2015 Estimate to a total of $19.74 million, supporting fundamental research in STEM education. In FY 2016, DUE continues to focus on supporting the Administration's goal of generating 100,000 new effective STEM teachers and one million more STEM graduates through the Robert Noyce Teacher Scholarship Program (NOYCE) program—in conjunction with HRD's Excellence Awards in Science and Engineering (EASE) program. The IUSE activity serves as an umbrella for agency-wide investments in undergraduate STEM education. EHR's contribution to IUSE increases $36.08 million to a total of $120.08 million to allow for increased focus on research experiences as part of the undergraduate STEM experience.

Major Investments

EHR Major Investments
(Dollars in Millions)

Area of Investment	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
CIF21	-	$2.50	$2.84	$0.34	13.6%
GRF	149.62	166.72	168.75	2.03	1.2%
I-Corps	0.35	0.35	1.55	1.20	342.9%
NSF INCLUDES	-	-	3.00	3.00	N/A
INFEWS	-	-	6.00	6.00	N/A
Improving Undergraduate STEM Education (IUSE)	74.57	84.00	120.08	36.08	43.0%
NSF Research Traineeship (NRT)[1]	13.93	28.27	35.38	7.11	25.2%
SaTC	44.87	45.00	45.00	-	-
Understanding the Brain	5.17	5.00	11.00	6.00	120.0%

Major investments may have funding overlap and thus should not be summed.

[1] Outyear commitments for Integrative Graduate Education and Research Traineeship (IGERT) are included in the NRT line and are $13.34 million in FY 2014, $4.40 million in FY 2015, and $2.85 million in FY 2016.

- Cyberinfrastructure Framework for 21st Century Science, Engineering, and Education (CIF21): In FY 2016, through the Project and Program Evaluation (PPE) program, $2.84 million will support CIF21's building community and capacity for data intensive research activity.

- Graduate Research Fellowship (GRF): GRF increases $2.03 million to a total of $168.75 million. An equivalent investment ($168.75 million) is provided through the Integrative Activities budget for a total GRF investment of $337.50 million. For more information, see the Major Investments in STEM Graduate Education narrative within the NSF-Wide Investments chapter.

- NSF Innovation Corps (I-Corps™): In FY 2016, DUE will support EHR's participation in this activity at a level of $1.55 million.

- NSF INCLUDES: In FY 2016, $3.0 million will support the pilot of a new approach to empowering youth by engaging them directly in STEM. Funding aims to catalyze innovative discipline-specific initiatives. The pilot will build, implement, and assess models that are intended to fuel the demand for STEM learning by directly engaging the youth community at the middle grades level, catalyzing innate curiosity, generating excitement, and engaging learners by making science and technology fun in order to interest them in STEM.

- Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS): $6.0 million will support emphasis on the food-energy-water nexus research area through the NRT.

- Improving Undergraduate STEM Learning (IUSE): In FY 2016, EHR will lead the NSF-wide IUSE activity with an investment of $120.08 million and coordinate the participation of the Directorates for Biological Sciences (BIO), Engineering (ENG), and Geosciences (GEO). Research and Related Activities (R&RA) account funding will be retained within individual directorates and offices and totals $14.50 million for a Foundation IUSE investment of $134.58 million. For more information, see the IUSE narrative within the NSF-Wide Investments chapter.

- NSF Research Traineeship (NRT): The investment for FY 2016 NRT activities is $35.38 million, of which $7.0 million is dedicated to supporting Innovation in Graduate Education (IGE) for model design, innovation, and research in graduate student training and professional development. For more information, see the Major Investments in STEM Graduate Education narrative within the NSF-Wide Investments chapter.

- Secure and Trustworthy Cyberspace (SaTC): Through the CyberCorps®: Scholarship for Service (SFS) program, EHR will support SaTC activities at $45.0 million.

- Understanding the Brain (UtB): Through the EHR Core Research (ECR), IUSE, and DRK-12 programs, EHR will invest in cognitive and learning sciences research efforts at the level of $11.0 million to better understand brain function during learning and problem solving in specific domains of STEM education, and to translate and apply findings from neuroscience and cognition for the improvement of education. EHR investments also will support the preparation of the next generation of neuroscientists and cognitive scientists.

Summary and Funding Profile

EHR supports investment in core research in education and STEM learning as well as STEM education development and training. In FY 2016, the number of research grant proposals is estimated at 1,970. EHR expects to award approximately 250 research grants with an average annual award size and duration of $265,000 and 3.1 years, respectively.

EHR Funding Profile

	FY 2014 Actual Estimate	FY 2015 Estimate	FY 2016 Estimate
Statistics for Competitive Awards:			
Number of Proposals	4,049	4,500	4,600
Number of New Awards	701	845	875
Funding Rate	17%	19%	19%
Statistics for Research Grants:			
Number of Research Grant Proposals		1,925	1,970
Number of Research Grants		235	250
Funding Rate		12%	13%
Median Annualized Award Size		$226,400	$226,600
Average Annualized Award Size		$265,000	$265,000
Average Award Duration, in years		3.1	3.1

FY 2015 is the first year in which Research Grant Portfolio information is displayed for EHR

Program Monitoring and Evaluation

EHR continues its strong emphasis on evidence, through projects, programs, and investment portfolios that are evidence-based, evidence-building, and evidence-improving. In FY 2016, EHR will further consolidate program-based monitoring systems, initiate use of administrative data and on-going data collections for monitoring and evaluation, and fully integrate monitoring and evaluation investments. This work aligns closely with the CoSTEM 5-Year Strategic Plan Objective 2: Build and use evidence-

based approaches.[5] Using the joint NSF and Institute of Education Sciences (IES) report, *Common Guidelines for Education Research and Development*, released in late FY 2013, EHR will ensure that promising practices, key findings, and accumulated knowledge in evaluation are used and adapted for use internally and disseminated to the larger evaluation community.

The National Research Council (NRC) report *Monitoring Progress Toward Successful K-12 STEM Education* (2013) laid the groundwork for a significant effort launched in FY 2014 to develop indicators for tracking progress in preK-12 STEM education, an essential component in developing evidence-based programs. EHR and the National Center for Science and Engineering Statistics (NCSES), in collaboration with the National Center for Education Statistics (NCES) within IES, are coordinating efforts to adapt and implement data collection on these indicators within other national efforts.

EHR-based infrastructure and processes will be developed in collaboration with the NSF Evaluation and Assessment Capability (EAC), as appropriate. EHR experts in evaluation will provide expertise as needed within NSF and to other federal agencies engaged in STEM education program evaluation as a means of sharing best practices, developing tools for portfolio and data analysis, working toward the use of common metrics and instruments, and building collaborative expertise for STEM education evaluation across agencies.

External Evaluations and Committee of Visitors (COV) Completed in FY 2014

- An external evaluation of the CyberCorps®: Scholarships for Service (SFS) program, conducted by the Office of Personnel Management.
- The Graduate Research Fellowship (GRF) program evaluation conducted by the National Opinion Research Center (NORC) was completed in FY 2014.[6]
- Evaluation for the LSAMP Bridges to the Doctorate program was completed and a presentation by the evaluator was given in February 2014. The report is awaiting final publication.
- ADVANCE completed a COV in September 2014.

External Evaluations Scheduled for Completion in FY 2015

- The NOYCE and NSF Scholarships for STEM (S-STEM) have received draft reports. Completion of these reports is expected in FY 2015.

COVs tentatively scheduled for FY 2015 and FY 2016[7]

- DRL plans to hold a division-wide COV in March 2015 to review all DRL programs—i.e., AISL, DRK-12, Innovative Technology Experiences for Students and Teachers (ITEST), Math and Science Partnership (MSP), Promoting Research and Innovation in Methodologies for Evaluation (PRIME) (a component of the PPE program), and Research on Education and Learning (REAL).
- DGE will hold COVs of the Integrative Graduate Education and Research Traineeship (IGERT) and SFS programs in FY 2015.
- HRD will hold COVs of Alliances for Graduate Education and the Professoriate (AGEP), CREST, HBCU-UP, LSAMP, and TCUP in FY 2016.
- The following programs in DUE are scheduled to be reviewed by COVs in FY 2015: ATE, NOYCE, S-STEM, STEM Talent Expansion Program (STEP), Transforming Undergraduate Education in STEM (TUES), and Widening Implementation and Demonstration of Evidence-Based Reforms (WIDER).

[5] www.whitehouse.gov/sites/default/files/microsites/ostp/stem_stratplan_2013.pdf
[6] www.norc.org/Research/Projects/Pages/evaluation-of-the-graduate-research-Fellowship-Program-.aspx
[7] Several programs listed (e.g., REAL, IGERT, STEP, TUES, and WIDER) have ended; however, the COVs are retrospective and will include them.

- An evaluation of EHR Monitoring Data Collection, Analysis, and Storage is scheduled to be completed in October 2015.

The Performance chapter provides details regarding the periodic reviews of programs and portfolios of programs by external COVs and directorate Advisory Committees. Please see the Performance chapter for additional information.

Number of People Involved in EHR Activities

	FY 2014 Actual Estimate	FY 2015 Estimate	FY 2016 Estimate
Senior Researchers	5,533	5,700	6,400
Other Professionals	5,420	5,600	6,300
Postdoctorates	244	300	300
Graduate Students	10,109	10,500	11,700
Undergraduate Students	13,330	13,900	15,400
K-12 teachers	36,134	37,600	41,800
K-12 Students	72,980	76,000	84,400
Total Number of People	**143,750**	**149,600**	**166,300**

DIVISION OF RESEARCH ON LEARNING IN FORMAL AND INFORMAL SETTINGS (DRL)

$253,080,000
+$31,560,000 / 14.2%

DRL Funding
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Request Amount	Change Over FY 2015 Request Percent
Total, DRL	**$230.13**	**$221.52**	**$253.08**	**$31.56**	**14.2%**
Learning and Learning Environments	**25.39**	**25.63**	**49.27**	**23.64**	**92.2%**
EHR Core Research (ECR): STEM Learning [1]	25.39	25.63	49.27	23.64	92.2%
Broadening Participation & Institutional Capacity	**147.22**	**138.81**	**151.93**	**13.12**	**9.5%**
Advancing Informal STEM Learning (AISL)	54.84	55.00	60.00	5.00	9.1%
Discovery Research K-12 (DRK-12)	92.38	83.81	91.93	8.12	9.7%
STEM Professional Workforce	**57.52**	**57.08**	**51.88**	**-5.20**	**-9.1%**
INSPIRE	0.10	-	-	-	N/A
Science, Technology, Engineering, Mathematics + Computing (STEM + C) Partnerships	57.43	57.08	51.88	-5.20	-9.1%

Totals may not add due to rounding.

[1] For comparability, Research on Education and Learning (REAL) is included on the EHR Core Research (ECR) line for FY 2014 because the program was consolidated into ECR in FY 2015 and FY 2016.

The Division of Research on Learning in Formal and Informal Settings (DRL) manages investments in foundational research to advance understanding about STEM learning and teaching. The DRL portfolio also includes the design, implementation, and study of learning environments, models, and technologies intended to engage and enable STEM learning for all students, particularly those who have been underrepresented in STEM, through both formal and informal STEM activities. DRL provides direction for the EHR portfolio in techniques for measurement and assessment of learning outcomes, and for the development of indicator tools that would enable the tracking of systemic improvement. The results of DRL-funded projects are a resource for establishing renewed and new partnerships with other directorates, NSF-funded facilities, other federal agencies, and the private sector for complementary investments in discipline- and practice-based approaches to STEM education.

DRL is the administrative home and provides intellectual leadership for: EHR's Core Research (ECR) portfolio; the EHR-wide emphasis on cyberlearning; collaborations with other directorates on big data, data science, and privacy related to learning data; agency-wide participation in citizen science and maker movement investments; a partnership with the Wellcome Trust for research on informal STEM learning; an ongoing set of efforts related to indicators for K-12 STEM education; and the NSF Einstein Fellows program.

FY 2016 Summary

All funding decreases/increases represent change over the FY 2015 Estimate.

Learning and Learning Environments

- In FY 2016, the ECR program will continue to expand the portfolio of foundational STEM education research on learning, learning environments, broadening participation, and the STEM professional workforce. An area of emphasis within the learning and learning environments theme for FY 2016 will be early childhood STEM learning, which will be highlighted in ECR along with the Research in Disabilities Education (RDE) and Research on Gender in Science and Engineering (GSE) emphases,

both of which will be continued. Increased funding will enable more strategic and coordinated research investment in areas of high importance for improving STEM learning. DRL will also provide new direction for partnership with science-rich entities funded across the NSF, such as major facilities, centers, and large instruments, in order to explore the potential of these learning environments for engaging and exciting STEM learners of all ages.

Broadening Participation and Institutional Capacity in STEM

- Broadening participation investments in FY 2016 will focus on understanding changing demographics and using diversity as an asset for science while also creating "bold visions" with the field for strategic focus (as part of the NSF INCLUDES activity). AISL increases to $60.0 million to provide resources to support design, adaptation, implementation, and research on innovative modes of learning in the informal environment, including emphases on citizen science, making, and cyberlearning. In addition to drawing on the resources of the informal STEM learning community to create a "bold vision" as part of NSF INCLUDES, AISL will partner with the LSAMP program to develop a pilot for empowering middle-school aged youth in STEM. AISL will continue to encourage projects that utilize informal learning environments in novel ways to engage students from groups traditionally underrepresented in STEM and continue with Phase 2 of the Wellcome Trust Science Learning+ collaboration, which are the partnership grants supporting joint U.S. and United Kingdom initiatives.
- DRK-12 investments (+$8.12 million to a total of $91.93 million) are aimed at improving STEM achievement for all preK-12 students, particularly those that have been underserved in STEM. These investments focus on cyberlearning and STEM discipline-specific teaching and challenges. STEM professionals and researchers, including teachers, must be agile and adaptable in order to keep pace with and contribute to deeper understandings about the technologies that inform their work, evidence-based instructional materials and assessment models, building and refining of science of learning ideas, and understanding how best to prepare the Nation's diverse learners for the future. The teacher education emphasis in DRK-12 continues its focus on implementation research on policy and practice issues associated with national and state activities, and on the role of authentic STEM research experiences in teacher development and in learning environment design as a means of reaching a wide range of students. In FY 2016, DRK-12 will include emphasis on research and development for early learning and on the preparation of teachers for future learning environments.

STEM Professional Workforce

- The STEM + Computing (STEM + C) Partnerships program advances research on and development of innovative courses, curriculum, course materials, pedagogies, instructional strategies, and models that integrate computing into one or more STEM disciplines. In addition, the program builds capacity in K-12 computing education with foundational research and focused teacher preparation. The program advances a 21st century vision for STEM education in which computing is integral to all STEM disciplines and essential to STEM learning and teaching. The total FY 2016 STEM + C Partnerships investment is $64.38 million, comprising a commitment from CISE of $12.50 million and $51.88 million from EHR, a decrease of $5.20 million in order to evaluate how best to invest future funding to encourage strong proposals that achieve the program's goals .

DIVISION OF GRADUATE EDUCATION (DGE) $295,640,000
+$22,230,000 / 8.1%

DGE Funding
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, DGE	**$245.58**	**$273.41**	**$295.64**	**$22.23**	**8.1%**
Learning and Learning Environments	**21.26**	**15.50**	**21.47**	**5.97**	**38.5%**
Project and Program Evaluation (PPE)	21.26	15.50	21.47	5.97	38.5%
STEM Professional Workforce	**224.31**	**257.91**	**274.17**	**16.26**	**6.3%**
EHR Core Research (ECR): STEM Professional Workforce Preparation[1]	15.89	15.97	20.09	4.12	25.8%
CyberCorps®: Scholarship for Service (SFS)	44.87	45.00	45.00	-	-
NSF INCLUDES	-	-	3.00	3.00	N/A
INSPIRE	-	1.95	1.95	-	-
Graduate Research Fellowship (GRF)	149.62	166.72	168.75	2.03	1.2%
NSF Research Traineeship (NRT)[2]	13.93	28.27	35.38	7.11	25.2%

Totals may not add due to rounding.

[1] For comparability, Research on Education and Learning (REAL) is included on the EHR Core Research (ECR) line for FY 2014 because the program was consolidated into ECR in FY 2015 and FY 2016.

[2] Outyear commitments for Integrative Graduate Education and Research Traineeship (IGERT) are included in the NRT line and are $13.34 million in FY 2014, $4.40 million in FY 2015, and $2.85 million in FY 2016.

The Division of Graduate Education (DGE) provides support to U.S. graduate students and innovative graduate programs to prepare tomorrow's leaders in STEM. In FY 2016, DGE leads the EHR focus on the STEM Professional Workforce thematic area and in addition to emphases on graduate education will include an increased interaction with other EHR divisions in such areas as teacher development and early career development of the STEM workforce. The resulting body of research expands the knowledge base that informs successful approaches, practices, and models for the preparation of a STEM professional workforce ready to advance the frontiers of science.

DGE provides the administrative leadership for two major NSF-wide graduate programs: the Graduate Research Fellowship Program (GRF) and the NSF Research Traineeship Program (NRT). DGE also co-leads the Interagency Working Group on Graduate Education for the Federal Committee on STEM Education.

FY 2016 Summary

All funding decreases/increases represent change over the FY 2015 Estimate.

Learning and Learning Environments

- PPE increases $5.97 million to a total of $21.47 million. Administrative oversight for EHR's activity in evaluation, monitoring, and related research activities will include launching long-term studies to examine the impact of NSF investment in graduate students and funding the development of instruments to assess metrics identified in the NRC report, *Monitoring Progress Toward Successful K-12 STEM Education* (2013). The Promoting Research and Innovative Methodologies for Evaluation (PRIME) activity within the PPE program will support research projects to improve STEM education evaluation, placing an emphasis on data privacy in research and evaluation and use of administrative data in evaluation.

STEM Professional Workforce

- ECR: STEM Professional Workforce Preparation increases $4.12 million to a total of $20.09 million. Investments in this area will expand the knowledge base to improve STEM professional workforce development (at all educational levels) through development of models, research, and evaluation, and will allow translation of the results of this research for adoption and/or adaptation in workforce and education programs.
- SFS funding is $45.0 million in FY 2016, equal to the FY 2015 Estimate. Funding will improve the capacity of institutions to provide the latest curricular approaches and experiences available to ensure that the students are well prepared with cybersecurity skills and knowledge, and to conduct research to build understanding of the most effective preparation for a variety of cybersecurity professions. Due to greater capacity, increased attention will be directed to community colleges, continuing an effort that was launched in FY 2015.
- The EHR portion of GRF increases $2.03 million to a total of $168.75 million. The program will support 2,000 new fellowships with a cost of education allowance of $12,000 and a stipend of $34,000. For more detailed information on this program, see the Major Investments in STEM Graduate Education narrative within the NSF-Wide Investments chapter.
- The EHR portion of NRT increases $7.11 million to a total of $35.38 million. This includes IGERT FY 2016 commitments totaling $2.85 million. IGERT commitments will be completed in FY 2016. The NRT investment supports projects in the FY 2016 NSF-wide priorities INFEWS and UtB. As part of the Innovation in Graduate Education track, NRT will challenge the field to devise cutting-edge innovations in preparing graduate students to be researchers in these evolving areas. For more detailed information on this program, see the Major Investments in STEM Graduate Education narrative within the NSF-Wide Investments chapter.

DIVISION OF HUMAN RESOURCE DEVELOPMENT (HRD) $145,590,000 +$1,860,000 / 1.3%

HRD Funding
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, HRD	**$139.21**	**$143.73**	**$145.59**	**$1.86**	**1.3%**
Learning and Learning Environments	**54.92**	**55.03**	**55.03**	**-**	**-**
ADVANCE	1.51	1.53	1.53	-	-
Alliances for Graduate Education and the Professoriate (AGEP)	8.18	8.00	8.00	-	-
Historically Black Colleges and Universities Undergraduate Program (HBCU-UP)	31.76	32.00	32.00	-	-
Tribal Colleges and Universities Program (TCUP)	13.47	13.50	13.50	-	-
Broadening Participation & Institutional Capacity	**58.33**	**58.88**	**60.74**	**1.86**	**3.2%**
EHR Core Research (ECR): Broadening Participation and Institutional Capacity in STEM[1]	12.82	12.88	14.74	1.86	14.4%
Louis Stokes Alliances for Minority Participation (LSAMP)	45.51	46.00	46.00	-	-
STEM Professional Workforce	**25.97**	**29.82**	**29.82**	**-**	**-**
Centers for Research Excellence in Science and Technology (CREST)	22.92	24.00	24.00	-	-
Excellence Awards in Science and Engineering (EASE)	3.05	5.82	5.82	-	-

Totals may not add due to rounding

[1] For comparability, Research on Education and Learning (REAL) is included on the EHR Core Research (ECR) line for FY 2014 because the program was consolidated into ECR in FY 2015 and FY 2016.

The goal of the Division of Human Resource Development (HRD) is to grow the innovative and competitive U.S. STEM workforce that is vital for sustaining and advancing the Nation's prosperity by supporting the broader participation and success of individuals currently underrepresented in STEM and the institutions that serve them. HRD supports research and development on theory-driven and evidence-based models and innovations in order to gain knowledge about the participation of diverse groups in STEM education and research.

In FY 2016, HRD will continue leading efforts to improve STEM education for Hispanic students through emphases on Hispanic-serving two-year community colleges and will work with several programs in EHR including ATE, IUSE, and LSAMP.

FY 2016 Summary

Learning and Learning Environments

- HRD supports STEM learning and learning environments through several existing programs (ADVANCE, AGEP, HBCU-UP, and TCUP). These programs will continue to build on the knowledge about successful approaches to broadening STEM participation and building institutional capacity in minority-serving institutions so they can contribute in this knowledge building. ADVANCE will continue to support work in institutional transformation and faculty development, as

well as focus on disciplinary areas that foster collaborations through developing networks and partnerships. AGEP will develop new strategies to work with the NRT and GRF programs to increase STEM career opportunities and access for graduate and postdoctoral students. Both HBCU-UP and TCUP continue to focus on institutional capacity building to provide more innovative activities for STEM learning.

- HRD programs will support learning issues in specific STEM disciplines, with an emphasis in mathematics in order to engage a more diverse group of learners.

Broadening Participation and Institutional Capacity in STEM

- HRD will provide strategic direction and guidance for the Broadening Participation and Institutional Capacity component of ECR. EHR will invest $14.74 million in foundational research to explore such topics as: approaches to using diversity as an asset for science; successful approaches that engage a diverse group of learners and audiences; the use of culturally relevant materials in engaging learners from groups traditionally underrepresented in STEM; and development and implementation of models that support persistence, retention, and success in STEM for groups underrepresented in STEM disciplines.
- New coordinated efforts will be built between the LSAMP program and the IUSE and ATE programs to enhance persistence of undergraduate students, and with the GRF program to increase the diversity of the GRF applicant pool. In addition, the LSAMP program will partner with DRL's AISL program in the development of the NSF INCLUDES: Empowering All Youth for STEM pilot program. The goal of this pilot is to build, implement, and assess models that are intended to fuel the demand for STEM learning by directly engaging the youth community at the middle grades level. Investments will focus on catalyzing innate curiosity, generating excitement, and engaging learners in relevant science and technology. Research indicates that students who developed "science identities" by the end of middle school have greater potential for their continued engagement in STEM.[8,9,10] HRD will lead EHR efforts to incorporate the principles of NSF INCLUDES across all programs in the directorate as appropriate, and will also play a key role in the development of metrics and approaches to the assessment of NSF INCLUDES and other investments in broadening participation.
- HRD will continue to represent EHR in the agency-wide NSF Broadening Participation Working Group and will contribute to the development of strategies to increase coherence across NSF's broadening participation activities. Members of the HRD executive staff have leadership roles as part of the FC-STEM Task Force. HRD staff co-lead, with NIH, the Interagency Working Group on Underrepresented Minorities. Through various discussions with HRD communities, individual PIs will be encouraged to contribute to the bold visions through proposals that support broadening participation as intellectual merit not simply as broader impact.

STEM Professional Workforce

- EASE will continue to support professional development for K-12 teachers and STEM educators and mentors, as well as the identification and recognition of educators who have particular impact on broadening participation.

[8] Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B. and Wong, B. (2010), "Doing" science versus "being" a scientist: Examining 10/11-year-old schoolchildren's constructions of science through the lens of identity. Sci. Ed., 94: 617–639.
[9] Barton, A. C., Kang, H., Tan, E., O'Neill, T. B., Bautista-Guerra, J., & Brecklin, C. (2012), Crafting a Future in Science Tracing Middle School Girls' Identity Work Over Time and Space. American Educational Research Journal, 83: 432-479. <http://aer.sagepub.com/content/50/1/37>.
[10] Bøe, M.V., Henriksen, E.K., Lyons, T. and Schreiner, C. (2011), Participation in science and technology: young people's achievement-related choices in late-modern societies, Studies in Science Education, 47:1, 37-72. <http://dx.doi.org/10.1080/03057267.2011.549621>.

DIVISION OF UNDERGRADUATE EDUCATION (DUE) $268,260,000 +$40,920,000 / 18.0%

DUE Funding
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total, DUE	**$217.10**	**$227.34**	**$268.26**	**$40.92**	**18.0%**
Learning and Learning Environments	**90.54**	**100.10**	**139.82**	**39.72**	**39.7%**
EHR Core Research (ECR): STEM Learning Environments[1]	15.97	16.10	19.74	3.64	22.6%
Improving Undergraduate STEM Education (IUSE)	74.57	84.00	120.08	36.08	43.0%
STEM Professional Workforce	**126.55**	**127.24**	**128.44**	**1.20**	**0.9%**
Advanced Technological Education	63.61	66.00	66.00	-	-
NSF Innovation Corps (I-Corps™)	0.35	0.35	1.55	1.20	342.9%
Robert Noyce Teacher Scholarship	62.59	60.89	60.89	-	-

Totals may not add due to rounding.

[1] For comparability, Research on Education and Learning (REAL) is included on the EHR Core Research (ECR) line for FY 2014 because the program was consolidated into ECR in FY 2015 and FY 2016.

EHR's Division of Undergraduate Education (DUE) supports the design, development, and study of innovative STEM learning environments that integrate cutting-edge science and education findings to optimize learning for all undergraduates. DUE invests in "learning engineering" where disciplinary expertise and evidence from the learning sciences are infused into physical and virtual tools, technologies, and other learning experiences, and then iteratively improved through research and development to impact STEM learning. The undergraduate experience is critical for building a STEM workforce and a STEM-literate public, and DUE is the leading organization across all Federal agencies for investing in research and development to transform undergraduate STEM education.

In FY 2016, DUE activities will support STEM learning engineering by investing in the design and transformation of environments for undergraduate STEM interdisciplinary and disciplinary learning, and by catalyzing high quality "discipline-based educational research,"[11] where questions of teaching and learning are driven by specific needs and issues within the scientific disciplines. DUE will support research designed to lead to widespread, sustainable implementation of evidence-based practices for the improvement of student outcomes. Such practices include engaged student learning interventions and course-based research experiences, and NSF-supported research shows that these result in improved student outcomes, including retention and persistence.[12]

DUE will provide NSF-wide programmatic leadership for encouraging impactful innovation in the preparation of undergraduates for emerging opportunities in global, interdisciplinary, and data-intensive science. DUE will partner formally with the Division of Human Resource Development (HRD) in the coordination of investments in community college STEM education, as well as undergraduate investment in institutions that serve large numbers of students from groups traditionally underrepresented in STEM.

[11] National Research Council. *Discipline-Based Education Research: Understanding and Improving Learning in Undergraduate Science and Engineering*. Washington, DC: The National Academies Press, 2012.
[12] Freeman S, et al. (2014) Active learning increases student performance in science, engineering, and mathematics. Proc Natl Acad Sci USA 111(23):8410–8415.

DUE provides administrative leadership for EHR in IUSE, the community college investment portfolio, and in the FC-STEM Interagency Working Group on Undergraduate Education. Additionally, DUE funds a center that leverages the expertise of the Advanced Technological Education grantee community to provide technical support to the Department of Labor Trade Adjustment Assistance Community College and Career Training (TAACCCT) program awardees preparing technicians in STEM fields.

FY 2016 Summary

All funding decreases/increases represent change over the FY 2015 Estimate.

Learning and Learning Environments

- ECR: STEM Learning Environments increases $3.64 million to a total of $19.74 million. DUE has leadership for this ECR focus area. The increase will support foundational research and related development for the improvement of STEM learning environments, including cyberlearning, as well as the use of data science to understand and improve learning environments.
- IUSE increases $36.08 million to a total of $120.08 million. This increase will provide support for and build upon FY 2015 collaborations established with BIO, GEO, and ENG to integrate undergraduate education efforts for greater coherence and discipline-specific impact across all NSF directorates in FY 2016. Expert staff in DUE will provide leadership for IUSE NSF-wide. Research and development on learning environments that bring together frontier science, quality experiences with disciplinary practices, and effective instructional strategies will be a focus in IUSE across NSF. Areas of specific interest in FY 2016 include research experiences extending beyond the traditional summer apprenticeship model, interventions to address low success rates in the mathematics courses typically taught in the first two years of college, and strategies to increase widespread implementation of evidence-based teaching practices. For more information regarding IUSE and NSF's undergraduate framework, see the IUSE narrative in the NSF-Wide Investments chapter.
- As part of IUSE, DUE will take leadership for EHR in working with the OIA Evaluation and Assessment Capability in FY 2015 and FY 2016 on implementation of common metrics and outcomes for undergraduate investments NSF-wide, and for possible use in the work of CoSTEM.
- DUE will work with HRD to align IUSE and S-STEM (an H-1B Visa funded program) with the LSAMP program to leverage the strengths of all programs for enhancing persistence of students from low-income and underrepresented groups. This alignment will be informed by a HRD and DUE-funded study by the National Academies on *Barriers and Opportunities in Completing Two or Four Year STEM Degrees.*[13]

STEM Professional Workforce

- The request for ATE is $66.0 million, equal to the FY 2015 Estimate. NOYCE remains consistent with the FY 2015 Estimate level of $60.89 million. ATE and NOYCE activities will include research on effective preparation of advanced technology technicians and teachers. In addition, both programs have emphasis on the preparation of a diverse STEM workforce and will incorporate a broadening participation focus. The FY 2016 I-Corps™ contribution is $1.55 million. The increase in I-Corps™ addresses the growing readiness in the EHR PI community to scale successful research-based educational innovations.

[13] Board on Science Education. *Barriers and Opportunities in Completing Two or Four Year STEM Degrees*. http://sites.nationalacademies.org/DBASSE/BOSE/CurrentProjects/DBASSE_080405

H-1B NONIMMIGRANT PETITIONER FEES

$100,000,000
$0 / 0.0%

In FY 2016, H-1B Nonimmigrant Petitioner Fees are projected to be $100.0 million, equal to the FY 2015 estimate.

H-1B Nonimmigrant Petitioner Fees Funding

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Percent
H-1B Nonimmigrant Petitioner Fees Funding	$129.41	$100.00	$100.00	-	-

Beginning in FY 1999, Title IV of the American Competitiveness and Workforce Improvement Act of 1998 (P.L. 105-277) established an H-1B Nonimmigrant Petitioner Account in the general fund of the U.S. Treasury for fees collected for each petition for alien nonimmigrant status. That law required that a prescribed percentage of funds in the account be made available to NSF for low-income scholarships; grants for mathematics, engineering, or science enrichment courses; and systemic reform activities. In FY 2005, Public Law 108-447 reauthorized H-1B funding. NSF was provided with 40 percent of the total H-1B receipts collected. Thirty percent of H-1B receipts (75 percent of the receipts that NSF receives) are to be used for a low-income scholarship program, Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM). Ten percent of receipts (25 percent of the receipts that NSF receives) are designated for support of private-public partnerships in K-12 education through Innovative Technology Experiences for Students and Teachers (ITEST).

- **Low-income Scholarship Program: S-STEM**. The S-STEM program provides institutions with funds for student scholarships to encourage and enable academically talented U.S. students demonstrating financial need to enter the STEM workforce or STEM graduate school following completion of an associate, baccalaureate, or graduate degree in fields of science, technology, engineering, or mathematics. The program emphasizes the importance of recruiting students to STEM disciplines, mentoring and supporting students through degree completion, and partnering with employers to facilitate student career placement in the STEM workforce.

  Since its inception, the low-income scholarship program has received nearly 6,500 proposals from all types of colleges and universities and has made awards for 1,354 projects. In addition to scholarships, projects include a coherent ecosystem of student support activities featuring close involvement of faculty, student mentoring, academic support, curriculum development, and recognition of the students. Such activities are important in recruiting and retaining students in high-technology fields through graduation and into employment. In FY 2016, in addition to the long-standing scholarship support, all S-STEM projects will contribute to the knowledge base of scholarly research in education by carrying out research on interventions which affect associate or baccalaureate degree attainment for academically talented U.S. students demonstrating financial need. Because S-STEM projects report much higher retention and graduation rates among their scholarship students than among other STEM majors, it is important to systematically study the reasons for this success. Approximately 85-90 awards are anticipated in FY 2016, with an emphasis on increasing involvement of community colleges, especially Hispanic-serving institutions. S-STEM activities in FY 2016 will leverage efforts in EHR's Division of Undergraduate Education's Improving Undergraduate STEM Education (IUSE) program and EHR's Division of Human Resource Development (HRD) Louis Stokes Alliances for Minority Participation (LSAMP) program to enhance

persistence of students. S-STEM programming and research emphasis will also align with the Division of Graduate Education's NSF Research Traineeship (NRT) program to understand and enhance development of effective learning environments and pathways for scholarship and traineeship students on the continuum from 2-year to 4-year to master's to doctoral degrees.

- **Private-Public Partnerships in K-12: ITEST**. The ITEST program invests in K-12 activities that address the current concern about shortages of STEM professionals and information technology workers in the U.S. and seeks solutions to help ensure the breadth and depth of the STEM workforce. ITEST funds activities for students and teachers that emphasize mathematics, science, and engineering careers, and emphasizes the importance of evaluation and research to understand the impact of such activities. The program supports the development, implementation, testing, and scale-up of models, STEM robotics projects, and research studies to improve the STEM workforce and build a student's capacity to participate in the STEM workforce. The solicitation places emphasis on capturing and establishing a reliable knowledge base about the dispositions toward and knowledge about STEM workforce skills in U.S. students.

  Since its inception, the ITEST program has received 4,387 proposals and funded 335 projects that allow students and teachers to work closely with scientists, engineers, and other STEM professionals on extended research projects ranging from biotechnology to environmental resource management to programming and problem-solving. Projects draw on a wide mix of local resources, including universities, industry, museums, science and technology centers, and school districts in order to identify the characteristics that attract a wide and diverse range of young people to STEM careers, especially those students not successful in traditional school settings. Approximately 20 awards are anticipated in FY 2016.

H-1B Financial Activities from FY 2005 - FY 2014

(Dollars in Millions)

	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Receipts	**$83.68**	**$105.32**	**$107.36**	**$104.43**	**$88.66**	**$91.22**	**$106.11**	**$128.99**	**$120.94**	**$132.49**
Unobligated Balance start of year	**$29.10**	**$89.58**	**$98.19**	**$63.37**	**$50.83**	**$52.62**	**$50.15**	**$60.93**	**$99.31**	**$104.76**
Appropriation Previously Unavailable (Sequestered)										**$5.10**
Appropriation Currently Unavailable (Sequestered)										**-$9.54**
Obligations incurred:										
Scholarships in Science, Technology, Engineering, and Mathematics[1]	0.54	80.95	100.04	92.40	61.22	75.96	77.67	72.57	83.98	92.18
Systemic Reform Activities	2.72									
Private-Public Partnership in K-12[2]	22.69	18.45	45.90	28.72	27.86	20.85	18.62	21.59	31.51	37.23
Total Obligations	**$25.95**	**$99.40**	**$145.94**	**$121.12**	**$89.08**	**$96.81**	**$96.29**	**$94.16**	**$115.49**	**$129.41**
Unallocated Recoveries					2.20	3.12	0.96	3.55		4.95
Unobligated Balance end of year	**$86.83**	**$95.50**	**$59.61**	**$46.68**	**$52.62**	**$50.15**	**$60.93**	**$99.31**	**$104.76**	**$108.35**

Totals may not add due to rounding.

[1] In FY 2006, the Computer Science, Engineering, and Mathematics Scholarships (CSEMS) was renamed to Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM).

[2] P.L. 108-447 directs that 10 percent of the H-1B Petitioner funds go toward K-12 activities involving private-publice partnerships in a range of areas such as materials development, student externships, math and science teacher professional development, etc.

Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM). The S-STEM program began in 1999 under P.L. 105-277. At this time, the program was named Computer Science, Engineering, and Mathematics Scholarships (CSEMS) and supported grants for scholarships to academically-talented, financially needy students pursuing associate, baccalaureate, or graduate degrees

in computer science, computer technology, engineering, engineering technology, or mathematics. Grantee institutions awarded scholarships of up to $2,500 per year for two years to eligible students.
The CSEMS activity continued under the American Competitiveness in the 21st Century Act (P.L. 106-313) with a prescribed percentage of H-1B receipts (22 percent) which totaled approximately 59.5 percent of the total H-1B funding for NSF. P.L. 106-313 also amended P.L. 105-277 by increasing the maximum scholarship duration to four years and the annual stipend to $3,125.

Under the Consolidated Appropriations Act, 2005 (P.L. 108-447), the prescribed percentage of H-1B receipts available for the low income scholarship program was increased to 30 percent (approximately 75 percent of the total H-1B funding for NSF). Eligibility for the scholarships was expanded from the original fields of computer science, engineering, and mathematics to include "other technology and science programs designated by the Director." The maximum annual scholarship award amount was raised from $3,125 to $10,000. Language also was added allowing NSF to use up to 50 percent of funds "for undergraduate programs for curriculum development, professional and workforce development, and to advance technological education." Because of these changes, the program was renamed in 2006 from Computer Science, Engineering, and Mathematics Scholarships (CSEMS) to S-STEM.

Systemic Reform Activities. Authorized under Title IV of the American Competitiveness and Workforce Improvement Act of 1998 (P.L. 105-277), these funds supplemented the rural systemic reform efforts administered under the former EHR Division of Educational System Reform (ESR).

Private-Public Partnerships in K-12. The American Competitiveness in the 21st Century Act (P.L. 106-313) amended P.L. 105-277 and changed the way petitioner fees were to be expended. P.L. 106-313 directed the remaining 40.5 percent of the total H-1B funding for NSF (15 percent of H-1B receipts) toward K-12 activities involving private-public partnerships in a range of areas such as materials development, student externships, and mathematics and science teacher professional development. The Information Technology Experiences for Students and Teachers (ITEST) program was developed as a partnership activity in K-12 to increase opportunities for students and teachers to learn about, experience, and use information technologies within the context of STEM, including information technology (IT) courses. In FY 2005, P.L. 108-447 reduced the prescribed percentage of H-1B receipts available for private-public partnerships in K-12 to 10 percent (approximately 25 percent of the total H-1B funding for NSF).

Explanation of Carryover

Within the **H-1B Nonimmigrant Petitioner** account, $108.35 million was carried over and consists of $27.09 million for Innovative Technology Experiences for Students and Teachers (ITEST) and $81.26 million for Scholarship in Science, Technology, Engineering, and Mathematics (S-STEM). Since NSF receives the largest payments of H-1B visa fees in August and September, there was insufficient time to obligate the receipts on awards before the end of the fiscal year. These resources will allow both ITEST and S-STEM to support awards through the second quarter of FY 2015.

MAJOR RESEARCH EQUIPMENT AND FACILITIES CONSTRUCTION

$200,310,000
-$450,000 / -0.2%

Major Research Equipment and Facilities Construction Funding
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Major Research Equipment and Facilities Construction	$200.00	$200.76	$200.31	-$0.45	-0.2%

The Major Research Equipment and Facilities Construction (MREFC) account supports the acquisition, construction, and commissioning of major research facilities and equipment that provide unique capabilities at the frontiers of science and engineering. Initial planning, design, and post-construction operations and maintenance are funded through the Research and Related Activities (R&RA) account. No new starts are proposed.

MREFC Account Funding, by Project
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	FY 2017 Estimate	FY 2018 Estimate	FY 2019 Estimate	FY 2020 Estimate	FY 2021 Estimate
AdvLIGO	$14.92	-	-	-	-	-	-	-
DKIST	36.88	25.12	20.00	20.00	20.00	16.13	-	-
LSST	27.50	79.64	99.67	67.12	55.80	47.89	45.75	39.90
NEON	93.20	96.00	80.64	-	-	-	-	-
OOI	27.50	-	-	-	-	-	-	-
Total	**$200.00**	**$200.76**	**$200.31**	**$87.12**	**$75.80**	**$64.02**	**$45.75**	**$39.90**

Totals may not add due to rounding.

Modern and effective research infrastructure is critical to maintaining U.S. leadership in science and engineering (S&E). The future success of entire fields of research depends upon access to new generations of powerful research tools. Increasingly, these tools are large and complex, and have a significant information technology component.

To be considered for MREFC funding, NSF requires that a project represent an exceptional opportunity to enable research and education. The project should be transformative in nature, with the potential to shift the paradigm in scientific understanding. The projects included in this budget request meet these criteria based on NSF and National Science Board (NSB) review.

In FY 2016, NSF requests funding to continue construction of three projects: the Daniel K. Inouye Solar Telescope (DKIST), the National Ecological Observatory Network (NEON), and the Large Synoptic Survey Telescope (LSST). The Advanced Laser Interferometer Gravitational Wave Observatory (AdvLIGO) and the Ocean Observatories Initiative (OOI) received their final construction funding in FY 2014. NSF is not requesting funds to begin any new projects in FY 2016. For more detailed information on these projects, please refer to the following individual narratives.

Since FY 2009, projects funded through the MREFC account have been subject to NSF's "no cost overrun" policy. As a result, NSF processes and procedures must assure the development of realistic and

well supported total project cost estimates for major research facilities such that approved budgets are sufficient to accomplish the scientific objectives.

The current policy requires that (1) the total project cost estimate when exiting the preliminary design phase includes adequate contingency to cover foreseeable risks, and (2) any cost increases not covered by contingency be accommodated first by reductions in scope; provided that the actual enacted funding levels have been consistent with the established annual cash flow requirements. NSF procedures are also designed to assure that contingency use tracking is robust, and that program and recipients have sufficient oversight and management authority (respectively) to meet project objectives. In FY 2014, NSF moved to improve its internal procedures by requiring an independent cost assessment for MREFC projects. In addition, all of the projects funded through the MREFC account undergo periodic cost, schedule, and risk reviews as required by NSF's Large Facilities Manual, as well as the terms and conditions of the cooperative agreements.

Appropriations Language

For necessary expenses for the acquisition, construction, commissioning, and upgrading of major research equipment, facilities, and other such capital assets pursuant to the National Science Foundation Act of 1950 (42 U.S.C. 1861 et seq.), including authorized travel, ~~$200,760,000,~~*$200,310,000*, to remain available until expended.

Major Research Equipment and Facilities Construction
FY 2016 Summary Statement
(Dollars in Millions)

	Enacted/ Request	Unobligated Balance Available Start of Year	Unobligated Balance Available End of Year	Adjustments to Prior Year Accounts	Transfers	Obligations Actual/ Estimates
FY 2014 Appropriation	$200.00	$0.38	-$0.39	$0.01	-	$200.00
FY 2015 Estimate	200.76	0.39			-	201.15
FY 2016 Request	200.31					200.31
$ Change from FY 2015 Estimate						-$0.84
% Change from FY 2015 Estimate						-0.4%

Totals may not add due to rounding.

Explanation of Carryover

Within the **Major Research Equipment and Facilities Construction** account an amount of $390,592 was carried over into FY 2015.

The MREFC Account in FY 2016

The following pages contain information on NSF's ongoing projects in FY 2016, grouped by sponsoring organization. These are:

DANIEL K. INOUYE SOLAR TELESCOPE $20,000,000

The FY 2016 Budget Request for the Daniel K. Inouye Solar Telescope (DKIST) is $20.0 million. This represents the eighth year in an eleven year funding profile, with an estimated total project cost of $344.13 million.

The original total project cost to NSF, $297.93 million, was finalized after a Final Design Review (FDR) in May 2009. The NSB approved an award for this amount at the NSF Director's discretion, contingent upon completion of compliance with relevant environmental and cultural/historic statutes. The environmental compliance requirements were completed on November 20, 2009, and the Record of Decision authorizing the construction was signed by the NSF Director on December 3, 2009. The Hawaii Board on Land and Natural Resources (BLNR) approved the project's application for a Conservation District Use Permit (CDUP) on December 1, 2010. A challenge to the CDUP organization was resolved in November 2012 and full access to the site atop Haleakala on Maui, Hawaii followed shortly thereafter. Site preparation and excavation began in December 2012.

The unexpected length of the delay associated with the environmental compliance process led to a reassessment of the project schedule and total project cost in early 2012. The revised baseline and an increase in the total project cost of approximately $46.20 million was reviewed by an external panel of experts and subsequently considered by the NSB, which approved a revised total project cost of $344.13 million at their August 2013 meeting.

Appropriated and Requested MREFC Funds for the Daniel K. Inouye Solar Telescope

(Dollars in Millions)

	Prior Years	FY 2013 Actual	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	FY 2017 Estimate	FY 2018 Estimate	FY 2019 Estimate	Total Project Cost
MREFC Approp.	$35.00	$25.00	$36.88	$25.12	$20.00	$20.00	$20.00	$16.13	$198.13
ARRA MREFC Appropriation	146.00	-	-	-	-	-	-	-	146.00
Total, DKIST	**$181.00**	**$25.00**	**$36.88**	**$25.12**	**$20.00**	**$20.00**	**$20.00**	**$16.13**	**$344.13**

Totals may not add due to rounding.

Baseline History

DKIST will enable the study of magneto-hydrodynamic phenomena in the solar photosphere, chromosphere, and corona. Determining the role of magnetic fields in the outer regions of the Sun is crucial to understanding the solar dynamo, solar variability, and solar activity, including flares and coronal mass ejections. These can affect civil life on Earth through the phenomena generally described as "space weather" and may have impact on the terrestrial climate. The relevance of DKIST's science drivers was reaffirmed by the National Academy of Sciences 2010 Astronomy and Astrophysics Decadal Survey: *New Worlds, New Horizons*[1] as well as the 2012 Solar and Space Physics Decadal Survey: *A Science for a Technological Society*.[2]

Beginning in 2001, NSF provided funds to the National Solar Observatory (NSO) for an eight-year design and development program for DKIST and its initial complement of instruments through the Division of Astronomical Sciences (AST) in the Directorate for Mathematical and Physical Sciences (MPS) and the

[1] www.nap.edu/catalog.php?record_id=12951
[2] www.nap.edu/search/?term=13060&x=0&y=0

Division of Atmospheric and Geospace Sciences (AGS) in Directorate for Geological Sciences (GEO). The current design, cost, schedule, and risk were scrutinized in an NSF-conducted Preliminary Design Review in October-November 2006. The FDR held in May 2009 determined that the project was fully-prepared to begin construction.

In FY 2009, $153.0 million was provided through the Major Research Equipment and Facilities Construction (MREFC) account to initiate construction. Of these MREFC funds, $146.0 million was appropriated through the American Recovery and Reinvestment Act (ARRA). Given the timing of the receipt of budget authority and the complexity of project contracting, the entire $153.0 million was carried over from FY 2009 and subsequently obligated in FY 2010. Since then, contracts for the acquisition of DKIST major subsystems and instruments have been issued. A Habitat Conservation Plan, designed to protect and rehabilitate habitats of the endangered Hawaiian petrel and Hawaiian goose that could potentially be affected by the construction of DKIST, has been approved by the Hawaii BLNR. Formal consultation with the U.S. Fish and Wildlife Service with regard to the endangered Hawaiian petrel was completed in calendar year 2011.

Total Obligations for DKIST

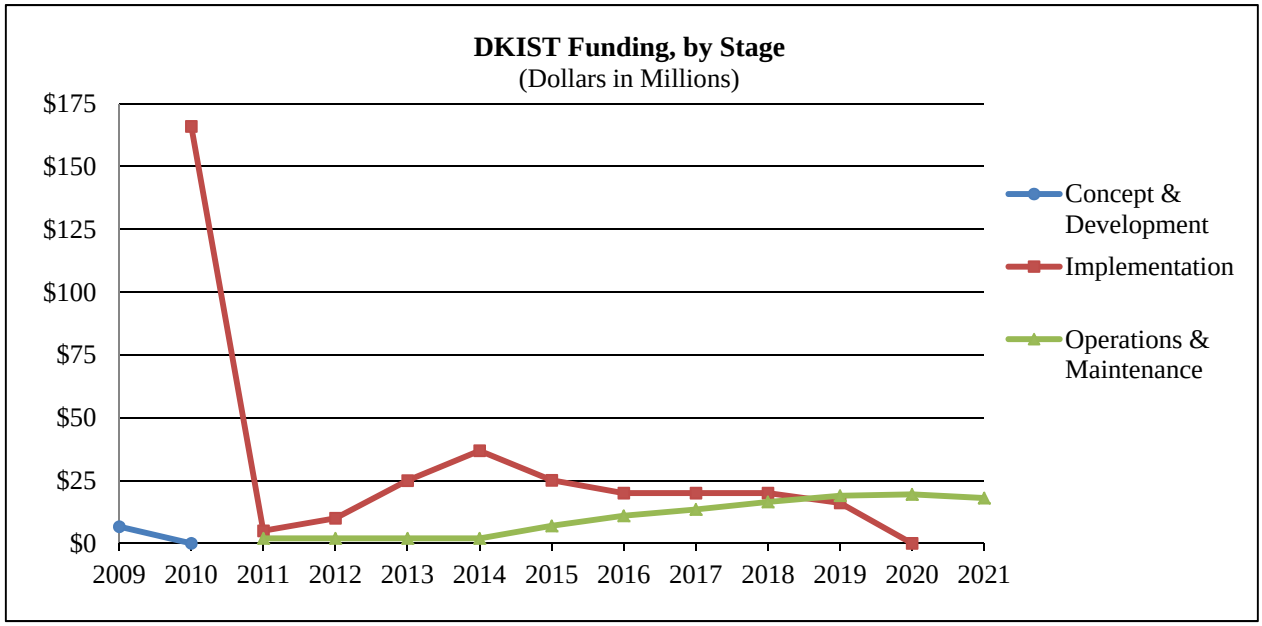
(Dollars in Millions)

					ESTIMATES				
	Prior Years[1]	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021
R&RA Obligations:									
Concept & Development	$20.41	-	-	-	-	-	-	-	-
Operations & Maintenance[2]	2.00	2.00	7.00	11.00	13.50	16.50	19.00	19.51	18.04
ARRA	3.10	-	-	-	-	-	-	-	-
Subtotal, R&RA Obligations	$25.51	$2.00	$7.00	$11.00	$13.50	$16.50	$19.00	$19.51	$18.04
MREFC Obligations:									
Implementation	60.00	36.88	25.12	20.00	20.00	20.00	16.13	-	-
ARRA	146.00	-	-	-	-	-	-	-	-
Subtotal, MREFC Obligations	$206.00	$36.88	$25.12	$20.00	$20.00	$20.00	$16.13	-	-
TOTAL Obligations	**$231.51**	**$38.88**	**$32.12**	**$31.00**	**$33.50**	**$36.50**	**$35.13**	**$19.51**	**$18.04**

Totals may not add due to rounding.

[1] Concept & Development funding and Implementation funding are cumulative of all prior years; Operations & Maintenance funding reflects prior year actual obligations only.

[2] Of the total Operations & Maintenance funding, $2.0 milllion per year for FY 2011 through FY 2020 is for cultural mitigation activities as agreed to during the compliance process.



The DKIST project is a collaboration of scientists and engineers at more than 20 U.S. and international organizations. Other potential partners include the Air Force Office of Scientific Research and international groups in Germany, the United Kingdom, and Italy. Now that there is firm funding for construction, details of these partnerships are being discussed. These include the following activities:

- The U.S. Air Force has replaced the aluminizing chamber at their Advanced Electro-Optical System telescope on Maui and sized it to accommodate the DKIST primary mirror. This obviates the need to build a new aluminizing chamber for DKIST.
- Kiepenheuer-Institut fuer Sonnenphysik (Freiburg, Germany) is constructing a narrow-band visible tunable filter based first-light instrument.
- Queens University Belfast (Belfast, Northern Ireland) is seeking funding for a contribution of high speed cameras for DKIST instrumentation.

Discussions of other possible contributions for second-generation instruments, algorithm development, coordinated observations, and student exchange are ongoing.

Management and Oversight

- NSF Structure: Oversight from NSF is handled by a program officer in AST working cooperatively with staff from MPS, the Office of Budget, Finance, and Award Management (BFA), and the Offices of the General Counsel and Legislative and Public Affairs. The Large Facilities Office, as part of BFA, also provides advice and assistance to program staff and assists with agency oversight and assurance.
- External Structure: The construction project is managed by NSO. NSF funds NSO operations and maintenance (O&M) and DKIST design and construction via separate cooperative support agreements (CSAs) beneath an overarching cooperative agreement (CA) with the Association of Universities for Research in Astronomy, Inc. (AURA). The NSO CA and O&M CSA were renewed for a period of ten years, starting in January 2015. This period covers the DKIST construction phase and the achievement of sustainable operations of the completed facility. The DKIST director is a senior NSO scientist who was a leader in the development of the science case and an expert in the field of solar adaptive optics, a critical technology for the DKIST. The project manager has experience in several other NSF-funded large projects including the Atacama Large

Millimeter/submillimeter Array and the Expanded Very Large Array. Several councils and working groups provide input from the solar and space physics communities.

Reviews

- Technical reviews: Reviews have been conducted throughout the design and development phase. The preliminary design was found to be robust in the NSF-conducted Conceptual Design Review in March 2005 and Preliminary Design Review in October-November 2006. The project has completed a comprehensive set of system-level design reviews for all major sub-systems.
- Management, Cost, and Schedule reviews: DKIST scope, schedule, budget estimate, and risk-adjusted total project cost were scrutinized and validated at the Preliminary Design and Final Design Reviews.
- Final Design Review (FDR): The FDR was held on May 18-21, 2009. The unanimous finding of the review panel was that the DKIST project was fully prepared to begin construction.
- Re-baseline review: A review of the revised project cost, schedule, and risk was held in October 2012. The project responded to the recommendations of the review panel and follow-up discussions were completed in April 2013. The new baseline was approved by the National Science Board and the NSF Acting Director in August 2013.
- Annual reviews of progress commence in early 2015.

Project Status

Current activities include finalizing the detailed construction-ready designs, ongoing fabrication of DKIST subsystems and instruments, and site preparation and excavation.

The mount base structure under construction. C*redit: M. Warner, DKIST.*

Haleakala High Altitude Observatory on the island of Maui was chosen as the DKIST site. The Final Environmental Impact Statement was submitted to the Environmental Protection Agency on July 24, 2009. Consultation with Native Hawaiian stakeholders has resulted in a fully-executed Programmatic Agreement that details steps to minimize impacts on the traditional cultural assets on Haleakala, thereby completing compliance with the National Historic Preservation Act. The record of decision authorizing the commencement of construction in FY 2010 was signed by the NSF Director and published in the Federal Register on December 9, 2009. All federal environmental compliance requirements are now complete. Following a challenge to the issuance of the State of Hawaii's Conservation District Use Permit, site access was granted in November 2012, at which time all relevant permits were in place.

Highlights of construction include:

- Erection of the telescope's support and operations building; this will continue throughout FY 2015.
- Assembly of the large, rotating enclosure (dome) site this will continue throughout FY 2015, starting with the installation of its track.
- The telescope mount assembly has completed factory acceptance test and is being shipped to Maui.
- The deformable mirror system was completed and integration and testing is ongoing.
- All first-light instrument detailed designs are complete and fabrication contracts have been let.

In FY 2016, the Support and Operations building will be completed and its Beneficial Occupancy Date achieved. Site testing of the Enclosure will be finished and the Telescope Mount Assembly Coudé Rotator will be installed in the pier. The Telescope Mount base erection will begin inside the facility, along with the start of the electrical installation. The instrument lab will be prepared in anticipation of use by the first light instruments in 2017. The Coudé Optics will pass through factory acceptance testing prior to shipment to Maui.

Cost and Schedule

The original baseline not-to-exceed, risk-adjusted cost was established following FDR. A revised project baseline review was held in October 2012; the National Science Board approved the new baseline in August 2013. Total project cost of $344.13 million is derived from ARRA ($146.0 million) and annual appropriations in the MREFC account ($198.13 million). Full science operations will begin in mid-2019.

Risks

Project management control, interface control, and change controls are in place. Delay in obtaining full access to the site and associated complexities and legal fees have impacted the total projected cost and schedule, resulting in a revised baseline cost and schedule.

The Coudé Rotator loaded down with dummy masses for final acceptance testing. *Credit: M. Warner, DKIST.*

Technical: The remaining technical risk is very low as a result of the long design and development phase.

Environmental and Cultural Compliance: AST, NSF's Office of the General Counsel and the DKIST project have worked carefully through the processes of the applicable statutes, and a cultural monitor has been retained during construction. All required permits are in place and twice annual consultations with a Native Hawaiian working group continue.

Environmental Health and Safety: NSO has a well-developed safety program engendered in the DKIST project. The DKIST project has developed a site safety plan and conducted a thorough construction readiness review in 2011 and conducts annual safety reviews.

Future Operations Costs

Estimated annual operations and maintenance cost is $17.0 million in FY 2019. DKIST will become the flagship telescope for the solar community, rendering some current facilities obsolete. NSO will realize significant savings through the closure or divestment of telescopes replaced by DKIST. A transition plan for the divestment of these facilities is part of the renewal of the NSO cooperative agreement and was externally reviewed. Cultural mitigation commitments have been made pursuant to terms of DKIST environmental and cultural compliance as described in the final environmental impact study and the subsequent Record of Decision, and the Programmatic Agreement. These include $2.0 million of R&RA funding annually for 10 years for programs on Maui, supporting science, technology, engineering, and mathematics education and workforce development with an emphasis on Native Hawaiian students. A ten-year award to develop and administer these programs was made to the University of Hawaii, Maui College in 2011.

Sunrise over the DKIST construction project atop Haleakala in December 2014. *Credit: B. Simison, DKIST.*

LARGE SYNOPTIC SURVEY TELESCOPE $99,670,000

The FY 2016 Budget Request for the Large Synoptic Survey Telescope (LSST) is $99.67 million. This is the third year of support for a nine-year project that began in August 2014. The total project cost to NSF is estimated at $473.0 million.

Appropriated and Requested MREFC Funds for the Large Synoptic Survey Telescope

(Dollars in Millions)

FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	FY 2017 Estimate	FY 2018 Estimate	FY 2019 Estimate	FY 2020 Estimate	FY 2021 Estimate	FY 2022 Estimate	Total Project Cost
$27.50	$79.64	$99.67	$67.12	$55.80	$47.89	$45.75	$39.90	$9.73	$473.00

Totals may not add due to rounding.

LSST Science Mission

LSST will be an 8-meter-class wide-field optical telescope designed to carry out surveys of nearly half of the sky. The initial 10-year survey has a cadence enabling repeat observation of each survey field approximately twice weekly. The requirements for LSST were defined by considering four key science areas:

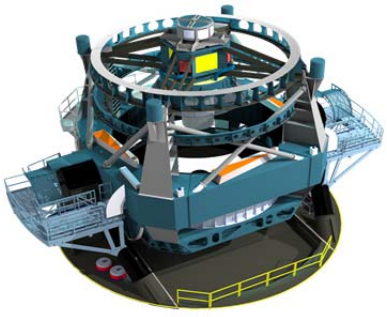
- Understanding the physics of dark energy and dark matter;
- Making a census of the small bodies in the solar system, including potentially hazardous Near Earth Objects;
- Mapping the structure and contents of the Milky Way galaxy;
- Understanding the nature of transient astronomical objects on time scales ranging from seconds to years.

By satisfying the requirements defined by these key investigations, the LSST survey also will result in a comprehensive data set that will enable hundreds of other fundamental astrophysical studies by the entire research community. Thus, LSST has the potential to change every field of astronomical study, from the inner Solar System to the large-scale structure of the Universe.

Baseline History

Construction of LSST is a joint NSF/Department of Energy (DOE) effort to realize an instrument that has been in design and development for over 15 years and that was ranked as the top large ground-based astronomy project by the National Research Council (NRC) 2010 Decadal Survey.[3]

Prior to NSF's MREFC construction award, over $130.0 million was invested by NSF, DOE, and private (non-federal) partners, with about 70 percent in design and development, and 30 percent, from the private funding, in early construction. The non-federal funding supported casting, figuring, and preliminary polishing of the innovative combined primary-tertiary mirror, initial site preparation, and prototype detector creation and evaluation, all of which have significantly reduced construction risks. The large design effort gives confidence in the final project cost estimate.



2013 rendering of the telescope. *Credit: LSST.*

[3] http://sites.nationalacademies.org/bpa/BPA_049810

Total Obligations for LSST

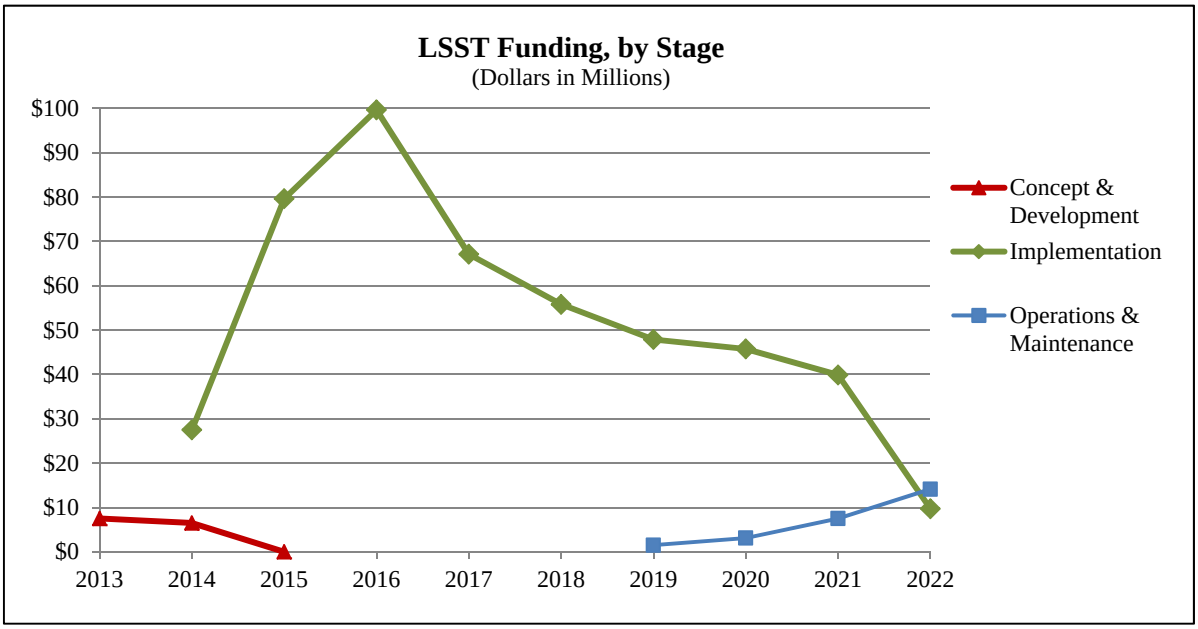
(Dollars in Millions)

	Prior Years[1]	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	ESTIMATES FY 2017	FY 2018	FY 2019	FY 2020	FY 2021
R&RA Obligations:									
Concept & Development	$50.63	$6.50	-	-	-	-	-	-	-
Operations & Maintenance	-	-	-	-	-	-	1.49	3.10	7.50
Subtotal, R&RA Obligations	$50.63	$6.50	-	-	-	-	$1.49	$3.10	$7.50
MREFC Obligations:									
Implementation	-	27.50	79.64	99.67	67.12	55.80	47.89	45.75	39.90
Subtotal, MREFC Obligations	-	$27.50	$79.64	$99.67	$67.12	$55.80	$47.89	$45.75	$39.90
TOTAL Obligations	**$50.63**	**$34.00**	**$79.64**	**$99.67**	**$67.12**	**$55.80**	**$49.38**	**$48.85**	**$47.40**

Totals may not add due to rounding.

[1] Concept & Development funding and Implementation funding are cumulative of all prior years; Operations & Maintenance funding begins in FY 2019.

The project was originally baselined following a series of reviews conducted by NSF and DOE in 2011 and 2012, including the NSF Preliminary Design Review (PDR) and a subsequent cost estimation review. Since that time, the construction plan has been kept up-to-date to synchronize the DOE and NSF funding profiles and adjust schedule contingency, as described below in the Cost and Schedule section.



LSST Science Plan

LSST will be an 8.4-meter primary, 6.7-meter effective aperture, special purpose optical telescope to be located on Cerro Pachón, Chile. The Chilean site was selected because of the excellent sky transparency and image quality ("seeing"), dark skies, small fraction of cloudy nights, and the geological characteristics that enable the rapid telescope motions required to carry out the LSST survey. LSST will collect nearly 40 terabytes of multi-color imaging data every night for 10 years, producing a long-lived dataset of considerable utility. It will produce the deepest, widest-field sky image ever, and issue alerts for moving and transient objects within 60 seconds of their discovery. Repeated deep imaging of every part of the accessible sky will turn up transient and explosive events such as cataclysmic variable stars, supernovae, and the optical counterparts of X-ray flashes, as well as less spectacular moving objects.

LSST data will be widely accessible, and discovery opportunities will be available to the K-12 student as well as to the professional astronomer. An innovative citizen science program will involve people of all ages in LSST discoveries. More than half of the cost during operations is for data management, including user-friendly interfaces tailored for the different anticipated communities. The survey strategy makes the same dataset usable for almost all of the astronomy community as well as for educators and the general public. The primary data archive will be located at the National Center for Supercomputing Applications (NCSA) in Illinois.

Management and Oversight

- NSF Structure: NSF oversight is the responsibility of the LSST program officer in the Division of Astronomical Sciences (AST) working with staff from the Directorate for Mathematical and Physical Sciences (MPS) and the Office of Budget, Finance, and Award Management (which includes the Large Facilities Office) through the newly-established Integrated Project Team (IPT) approach. The NSF program officer works closely with counterparts in the DOE Office of High Energy Physics, who have oversight responsibility for the LSST Camera sub-project. Inter-agency coordination is accomplished through regular meetings of a Joint Oversight Group (JOG) each week and was formalized through a memorandum of understanding (MOU) signed in July 2012.
- External Structure: The responsible awardee for LSST construction is the Association of Universities for Research in Astronomy (AURA), Inc., a non-profit science management corporation consisting of 39 U.S. institutional members and seven international affiliates. AURA works closely with the LSST Corporation (LSSTC), which initiated the LSST development and remains responsible for the privately raised funding. AURA and LSSTC established the LSST Project Office as an AURA-managed center for the construction period; this Project Office is overseen by the AURA Management Council for LSST. The LSST Project Director and the LSST Project Manager are experienced in large facility construction and operation and are appointed by AURA, with the involvement and approval of the LSSTC and NSF.

Reviews

- Technical Reviews: Reviews have been conducted throughout the design and development phases. A Conceptual Design Review (CDR), conducted in September 2007, found the design to be robust. The PDR followed release of the NAS 2010 Decadal Survey and was completed in September 2011. The DOE Critical Decision (CD) review of the camera led to CD-1 approval ("Approve Alternative Selection and Cost Range") in April 2012. All major sub-systems undergo regular system-level design reviews organized by the LSST Project Office with external participants.
- Management, Cost, and Schedule Reviews: Cost, schedule, and risk are scrutinized by all of the regular technical reviews. During construction, NSF and DOE will hold annual joint progress reviews. Specific milestone reviews for management, cost, and schedule also are described below:
    - Recommendations from the NSF PDR and the DOE CD-1 review led to a Joint Interface and Management Review and a Cost Estimation Review, both held in May 2012. DOE later held a status review of the camera sub-project in June 2013, which led to an increased duration for the LSST construction project, including additional schedule contingency, and a small increase in scope. These changes were necessitated when DOE was not permitted to begin the camera construction within their FY 2013 appropriation.
    - NSF's Final Design Review (FDR) was held in December 2013 with DOE involvement. Fifteen panelists with wide-ranging experience in large projects gave the project a thorough review. Although the final report includes 34 recommendations, these recommendations only adjust the relative emphasis of project activities or endorse existing plans. The panel concluded: "We have no hesitation in our assessment that the project will be ready for the start of construction on July 1, 2014." The National Science Board (NSB) authorized NSF management to proceed with the construction award on May 7, 2014 (NSB-14-24).

  - An NSF internal cost analysis in 2013 was followed by a Cost Estimation Sufficiency Review conducted by an independent contractor to validate the LSST Project's Basis of Estimate documentation. These checks were in addition to the FDR and to the 2012 and 2011 reviews. The external report gave the LSST cost estimate an overall rating assessment of Adequate. Ten evaluation areas met the adequacy standards, and NSF secured improvements to the estimate from the awardee in three areas.
- DOE CD-3a review (long lead procurements) was held on May 6 – 7, 2014 and CD-3a approval was issued in July.
- DOE CD-2 review was successfully completed in November 2014. CD-2 approval, including setting the not-to-exceed Total Project Cost for the DOE sub-project, was issued on January 7, 2015.

Project Status

NSF's construction award was issued on August 1, 2014. The project worked closely with NSF's Division of Acquisition and Cooperative Support (DACS) to satisfactorily resolve all major cost issues in accordance with the NSB resolution. Total project contingency estimates and the resulting Risk Register are undergoing a final internal NSF review with the Large Facilities Office and are expected to be settled in early FY 2015. Design and development support from both agencies enabled readiness for construction, including the preparation of "design with option to build" bid packages that can be awarded quickly. This sped up project activities during the first full year of MREFC support: major work packages for the Telescope Mount Assembly and for the Summit Facility were contracted early in FY 2015, with other contracts anticipated during the year, for example, for data management systems. DOE funding covered significant hardware purchases for the camera in FY 2014, which continue in FY 2015. NSF and DOE supported activities remain tightly coordinated, both at the project level and between agency program officers.

While the facility, telescope, and camera are being built, the project will continue to address data access, computation, and collaboration needs. Because there will be different communities of users, there will be various concurrent modes of access. Development of the data access policy is expected to be a continuing activity as there are multiple promising approaches, and the details continue to be the subject of very active discussion within the project, with internal and external advisory committees, and with potential international partners.

Cost and Schedule

After a delay in the camera construction schedule, a DOE status review in June 2013 concluded that additional time would be needed. This led to a complete bottom-up re-planning of the project prior to the NSF FDR. The FDR panel found the NSF Total Project Cost (TPC) of $473.0 million to be reasonable and justifiable if the project implements descoping options and also generates extra descope options that can be implemented later if additional risk reduction is necessary. The resulting extended schedule and TPC increase were predicated on a July 1, 2014 start for MREFC funding from NSF. While the actual date was August 1, 2014, this slight delay has not had a significant impact on this new schedule.

In addition to NSF's contribution, DOE's baseline for the camera was fixed at $168.0 million when CD-2 approval was issued on January 7, 2015. Project construction includes $38.97 million from non-federal sources, nearly all of which has been expended.

Risks

Technical: Much of the technical risk has been retired by design and development effort and by investment of non-federal funds in construction, notably for the primary-tertiary mirror, whose polishing was completed in late 2014. Both PDR and CD-1 external reviews identified the camera detectors as a possible risk; this risk continues to be reduced and the project mitigation strategy was again endorsed by a DOE-led status review in June 2013. The risk registry is continually monitored and updated.

Environmental and Cultural Compliance: The Chilean environmental and cultural impact assessment has been completed and was reviewed and subsequently approved by NSF in October 2010, under Executive Order 12114 for extraterritorial projects. Mitigation work has started with the propagation of threatened plant species, and the beginnings of reintegration at the site.

Site: The above environmental and cultural impact assessment, and the subsequent finding equivalent to no significant impact, cleared the way for the preliminary site work. Local contractors have leveled the planned location for LSST and confirmed the geological results from the original test borings. They found no problems that could compromise the stability and rigidity of the mount as currently designed. There appear to be no remaining site risks.

Environmental Health and Safety: The LSST project has a full-time Head of Safety with experience in AURA operations, which include a long positive safety record in Chile. AURA Safety Policy encompasses general guidelines as well as site-specific policies, such as a LSST summit-specific plan. These plans are fully compliant with applicable standards from U.S., Chilean, and participating institutions. The plans will be monitored and updated appropriately and will be reviewed annually.

Partnership Risk: The LSST Project Director oversees the entire project and will be assisted by a Deputy Project Director (to be appointed) with complementary skills and experience. Detailed project management is handled by a single Project Manager, agreed to by both NSF and DOE program management. Budgetary management details are clearly set out between the Project Director, the Project Manager, the project's Change Control Board, the AURA Management Council for LSST, and the agency program officers, grants officers, and financial managers. The commitments by DOE and by NSF were officially recorded in an MOU between the agencies that was signed in July 2012. As the MOU notes, the management structure treats the project as a single team and includes mechanisms and authority to make changes on either side of the DOE/NSF budgetary boundary, and across that boundary, if needed.

Operations Costs: A formal proposal for LSST Operations will be requested approximately two years before the start of early operations. Review of that proposal will result in the baseline project execution plan and operating costs. The project team has spent some effort on possible scope reduction to shrink the total annual cost but has primarily focused on finding partners willing to contribute towards the necessary non-federal contribution of approximately $9.0 million per year. Letters of commitment have been received from 68 institutions in 26 countries for a total annual contribution of over $10.0 million, providing strong confidence that the necessary non-federal contributions will be forthcoming. Negotiations have started for firm agreements and possible advance contributions. An LSST@Europe meeting in September 2013 had attendees from 20 countries and led to detailed discussions about those contributions and agreements. Given the signed NSF/DOE MOU and the high level of signatories to the partner letters of commitment, operational support risk is low. The LSST Project Office plans to form an international finance committee to oversee the use of contributed funds during operation.

Future Operations Costs

Estimated operations costs were calculated in FY 2013 U.S. dollars at $36.63 million per year. Following the recommendation of the NRC 2010 Decadal Survey, MPS/AST has prepared a plan to provide approximately 50 percent of that amount, and the DOE Office of High Energy Physics has committed to another 25 percent. As mentioned previously, the total estimated cost, and the amount required from the non-federal partners, will be determined in review of a future LSST Operations proposal. In their joint MOU, NSF and DOE have agreed together to fund operations, increasing agency support and/or revising the operations plans, as appropriate.

THE NATIONAL ECOLOGICAL OBSERVATORY NETWORK $80,640,000

The FY 2016 Budget Request for the National Ecological Observatory Network (NEON) is $80.64 million, which represents the last funding year of a six-year project that totals an estimated $433.72 million.

Appropriated and Requested Funding for the National Ecological Observatory Network

(Dollars in Millions)

Prior Years	FY 2012 Actual	FY 2013 Actual	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	FY 2017 Estimate	FY 2018 Estimate	Total Project Cost
$12.59	$60.30	$91.00	$93.20	$96.00	$80.64	-	-	$433.72

Totals may not add due to rounding.

NEON consists of geographically distributed field and lab infrastructure networked via cybertechnology into an integrated research platform for regional to continental scale ecological research. Cutting-edge sensor networks, instrumentation, experimental infrastructure, natural history archive facilities, and remote sensing will be linked via the internet to computational, analytical, and modeling capabilities to create NEON's integrated infrastructure.

Baseline History

In 2004, the National Research Council (NRC) evaluated the original NEON design of loosely confederated observatories and recommended that it be reshaped into a single integrated platform for regional to continental scale ecological research. Congress appropriated initial funding in FY 2007. A Preliminary Design Review (PDR) was completed in June 2009 and a Final Design Review (FDR) was completed in November 2009. The FDR also included a formal construction baseline review and cost review; an additional baseline review was conducted in April 2011 prior to initiation of construction that confirmed the baseline scope, cost, and schedule. Project planning continued through FY 2011 until construction began in August 2011.

Total Obligations for NEON

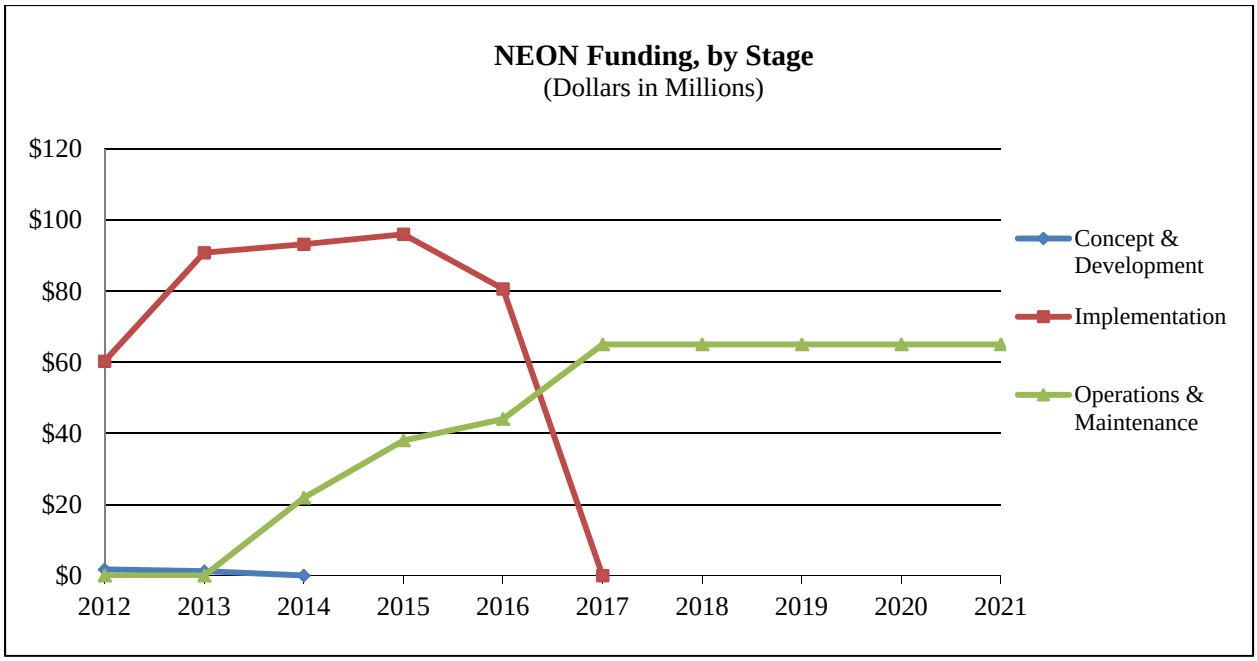
(Dollars in Millions)

	Prior Years[1]	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	ESTIMATES FY 2017	FY 2018	FY 2019	FY 2020	FY 2021
R&RA Obligations:									
Concept & Development	$91.73	-	-	-	-	-	-	-	-
Operations & Maintenance[2]	-	21.89	38.00	44.04	65.00	65.00	65.00	65.00	65.00
ARRA	9.96	-	-	-	-	-	-	-	-
Subtotal, R&RA Obligations	$101.69	$21.89	$38.00	$44.04	$65.00	$65.00	$65.00	$65.00	$65.00
MREFC Obligations:									
Implementation	163.89	93.20	96.00	80.64	-	-	-	-	-
Subtotal, MREFC Obligation	$163.89	$93.20	$96.00	$80.64	-	-	-	-	-
TOTAL Obligations	**$265.58**	**$115.09**	**$134.00**	**$124.68**	**$65.00**	**$65.00**	**$65.00**	**$65.00**	**$65.00**

Totals may not add due to rounding.

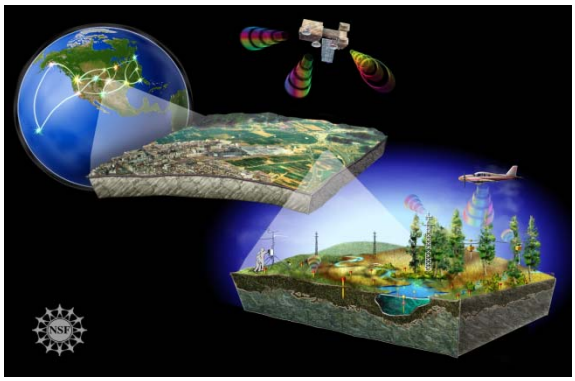
[1] Concept & Development funding and Implementation funding are cumulative of all prior years; Operations & Maintenance funding reflects prior year actual obligations only.

[2] Funding for Operations & Maintenance (O&M) in outyears has been capped at now-year dollars, pending the results of a three year initial O&M testing. A final O&M award, to be made after the three years concludes, will reflect these results.



NEON is the first research platform and the only national experimental facility specifically designed to collect consistent and standardized sensor and biological measurements across 106 sites nationwide in close to real-time, enabling basic research on complex phenomena driving ecological change and at the scales appropriate for studying many grand challenge questions in ecology. NEON allows researchers to expand the scale of their research to understand large scale dynamics affecting ecosystems.

A NEON cyberinfrastructure gateway provides resources to support formal and informal public education and provide opportunities for citizens to participate in scientific investigations. NEON data is open-access via web portals and available as soon as possible, once basic quality assurance and quality control procedures have been applied. Private organizations including the Heinz Center, National Geographic Society, Nature Serve, and the Ecological Society of America are assisting NEON, Inc. to broaden the impact of NEON science and education to the next generation of scientists and educators.



NEON will be a collaborative research platform of geographically distributed infrastructure connected via the latest information technology. By combining in-situ sensing with remote sensing observations, NEON will address pressing environmental questions on regional to continental scales. *Credit: NSF.*

The 2009 United States Global Change Research Program (USGCRP) assessments indicate that U.S. ecosystems will experience abrupt and unpredictable changes from a suite of human-driven processes in the near future.[4] NEON enables research on the impacts of climate and land use change, water use, and invasive species on the Nation's living ecosystems at temporal and spatial scales that are relevant to human well-being. NEON's unique statistically-determined, continental-scale design, with data products, data management, and standardization supports research on the dynamics of complex coupled systems needed for modeling and understanding rates of change on regional and continental scales. No other

[4] Global Climate Change Impacts in the United States, Thomas R. Karl, Jerry M. Melillo, and Thomas C. Peterson, (eds.). Cambridge University Press, 2009.

standalone system – federal or private – can provide the scientifically validated suite of data measurements that NEON provides.

The scientific techniques, sensor data, and basic research knowledge gained through NEON will inform federal resource management decisions necessitated by climate and land use change, water use, and invasive species. They will contribute to societal benefits as identified by the National Science and Technology Council's 2013 National Strategy for Civil Earth Observations and the international Group on Earth Observations 2004 Framework Document. The science that NEON supports is not bound by national boundaries, with regard to climate change, invasive species, and the ecological processes they affect. The repurposing of NEON data and information and establishing interoperability among all earth observations is important to enable the research on continental to global scales. NEON's domestic and international MOUs focus on meeting NEON, Inc.'s Strategic Plan and the U.S. National Plan for Civil Earth Observations both of which call for strengthening international collaboration in Earth Observations, and to improve data access, management, and interoperability.[5] Formal agreements have been signed with the European Union, including the Integrated Carbon Observing System (ICOS) Ecosystem Thematic Center, Infrastructure for Analysis and Experimentation on Ecosystems (AnaEE), Czech Climate Change Research Center (CzechGlobe), and Australia's Terrestrial Ecosystem Research Network (TERN). Areas of coordination include planning, design, construction, deployment, environmental assessment, data management, geospatial data exchange, cyberinfrastructure, research, and modeling. As described in an August 2013 article in the *Engineering News-Record*, NEON construction models are also having an impact on establishment of new standards for construction in environmentally sensitive areas.[6]

Management and Oversight

- NSF Structure: The NEON program is managed in the Directorate for Biological Sciences (BIO) Office of the Assistant Director (OAD/BIO) as part of the Emerging Frontiers (EF) subactivity. OAD/BIO provides overall policy guidance and oversight, and the location of the NEON program in EF within BIO fosters its broader biological and interdisciplinary science connections. The NEON program is managed by a dedicated program officer and a project manager with experience from another NSF MREFC project; two additional program officers participate in planning, development, and oversight of NEON construction and NEON operations and maintenance. An Integrated Project Team (IPT) chaired by the NEON program officer, with representatives from Large Facility Office (LFO), BFA, and program representatives from other NSF large facilities, advises and assists with the business framework of the project. The NEON program officer served as the contracting officer's representative (COR) for the NEON environmental assessment completed in FY 2010. A NEON Environmental Assessment Team (EA) provides ongoing technical advice on the National Environmental Policy Act (NEPA) compliance and NSF environmental policy.

- External Structure: The NEON project is funded through cooperative agreements with NEON, Inc., a non-profit, membership-governed consortium established to oversee the design, construction, management, and operation of NEON for the scientific community. Within NEON, Inc., the CEO provides overall leadership and management; the Project Manager oversees all aspects of the project design, review, construction, and deployment; the Observatory Director provides leadership for

[5] The US National Plan, which states '…to coordinate, plan, and assess Federal Earth observation activities in cooperation with domestic stakeholders; to foster improved Earth system data management and interoperability throughout the Federal Government; and to engage international stakeholders by formulating the U.S. position for, and coordinating U.S. participation in the intergovernmental Group on Earth Observations.' Holdren, J., T. Dickenson, G. Paulson, et al. 2014. *National Plan for Civil Earth Observations*, National Science and Technology Council, Executive Office of the President, pp. 71. www.whitehouse.gov/sites/default/files/microsites/ostp/NSTC/2014_national_plan_for_civil_earth_observations.pdf.

[6] http://enr.construction.com/technology/construction_technology/2013/0828-reaching-zero-the-realities-of-ecologicallyfriendly-engineering-on-a-continental-scale.asp

operations for the facility. A Board of Directors and a Science, Technology, and Education Advisory Committee (STEAC) composed of members of the NEON user community, each provide oversight and guidance to the project and help ensure that NEON will enable frontier research and education. A Program Advisory Committee (PAC) will be appointed in the second quarter of FY 2015, to provide advice and guidance to the NEON Observatory on the use of NEON facilities.

Reviews

- Technical reviews: The NEON Observatory Design Review (including site selection and deployment design) was successfully completed in February 2009.
- Environmental review: The NEPA environmental assessment was completed in November 2009. A "Finding of No Significant Impact" was signed by NSF in December 2009; the U.S. Fish and Wildlife Service concurred with this finding, as well as with NSF's compliance with the Endangered Species Act. In July 2011, the NSF Record of Decision was signed.
- Construction, Cost, and Schedule reviews:
  - A Conceptual Design Review was held in November 2006.
  - A combined Preliminary Design Review (PDR)/Final Design Review (FDR) of the airborne observation platform was successfully completed in February 2009.
  - A PDR for the entire project was successfully completed in June 2009.
  - An FDR was successfully completed in November 2009, including construction and cost reviews.
  - A Baseline Review, to ascertain readiness to begin construction, was conducted in April 2011 prior to construction.
  - A second Baseline Review was held May 2013 to ascertain the impacts of funding delays on project schedule. A Delta Review – to assess progress in implementing scheduling recommendations received from the baseline review panel – was held in December 2013.
  - A third successful Baseline Review was held in August 2014 confirming the schedule robustness and costs.
  - A Construction Review is conducted annually during the fourth quarter.
- National Science Board (NSB) Review: The Board reviewed and authorized NEON construction subject to final appropriation of funds in May 2010. The Board reviewed and authorized NEON O&M in February 2013.
- Management, Business, and Operations Reviews:
  - NSF conducted a Business Systems Review (BSR) and issued a final report in November 2011.
  - An Operations Review of the project's operating plan and costs for the first three years of operations was held in January 2012.
  - Annual operations and management reviews will be conducted each year starting in FY 2015.
  - A pre-award cost review is proposed prior to full observatory operations 5-year funding.

Project Status

The National Science Board approved funding for NEON in May 2010 and construction was initiated in August 2011. Construction of technical support facilities was completed in September 2013 and these facilities were used to support other construction activities. NEON's airborne observation platform provides remote sensing through aircraft-mounted instrumentation, including an imaging spectrometer operating in the visible to shortwave IR spectral region, a waveform light detection and ranging (wLiDAR) instrument, and a high-resolution digital camera deployed on three aircraft. The first two airborne observatories were constructed and pathfinder missions were conducted in FY 2013 with NASA and supported research studies and management of major forest fires. The third airborne observatory was delivered ahead of schedule and its pathfinder flights occurred in FY 2014. By the fourth quarter of FY 2015, the three airborne observatories will begin to transition to full Observatory operations with the transition complete in FY 2016.

Civil construction of distributed infrastructure is ahead of schedule and deployment of sensor assemblies is fully underway with the resolution of procurement and production difficulties. As a result, it is expected that 30 percent of the Observatory research capabilities will be available by the end of FY 2015 and 60 percent by the end of FY 2016. In FY 2015, civil and facility construction activities are planned for 35 sites in nine domains. By the end of FY 2015, 88 percent of the total civil and facility construction will be complete. The remaining Observatory civil construction at 14 sites in eight domains will be complete in FY 2016. The rate of instrumentation deployment and site commissioning has increased, with initial sensor deployment and commissioning completion anticipated at 33 sites in 15 domains in FY 2015 and full sensor deployment at 21 sites in 13 domains in FY 2016. In FY 2015, biological sampling will occur at 29 sites in 16 domains. In FY 2016, biological sampling is proposed for 26 sites in 15 domains. Aquatic and Stream Experimental and Observatory Network (STREON) site construction is proposed to include 11 sites in nine domains in FY 2015 and 20 sites in 19 domains in FY 2016. In FY 2015, one of the STREON sites will transition to operations and in FY 2016 three STREON sites will become operational.

In FY 2015 and FY 2016, MREFC funds will support continuation of the NEON cyberinfrastructure hardware and software deployments in support of sites and domain Support Facilities acceptance. Funds were requested in FY 2015 to continue data center expansion, to complete biological sampling personal data assistants and NEON central operational support system, and ongoing development of data algorithms and related data release via NEON's web portal. In FY 2016, funds will be used to expand the operational support systems, management system for assets, configuration, inventory, and ongoing development of data algorithms and related data release via NEON's web portal.

In FY 2016, $44.04 million is requested from the Research and Related Activities (R&RA) account for operations and maintenance of the fourteen domains commissioned, including related management and technical support, seasonal biological sampling, analytical and archival costs, and domain facilities costs. Funds will support the Calibration & Validation Laboratories and headquarters functions, such as maintenance of the data center, Observatory monitoring and quality assurance and control. In addition, funds will support the operation and maintenance of the Airborne Observation Platform and related technical facility.

Cost and Schedule

The projected length of the construction project is six fiscal years, with a six-month schedule contingency included. NEON is currently 48.5 percent complete. Current project performance is consistent with ending on time and within budget.

Risks

Technical: Dependence on commercial off-the-shelf technology from single vendors will be mitigated by procurements to enable testing and identification of alternative vendors. Production quality, embedded and system-level cyberinfrastructure will be addressed by a combination of "in-house" design, commercial contracts, and targeted research (e.g., cyber-dashboard). While the bulk of NEON's infrastructure and instrumentation will be "commercial off-the-shelf," NEON's scientific and networking design required certain technological innovations for a small number of components. Consequently, BIO has provided R&RA funds for advanced research and development (R&D) activities in the areas of sensors, cyberinfrastructure, and remote sensing technology. These development activities are progressing with adequate margin to meet the delivery milestones.

Deployment: Environmental assessment and permitting may impact schedule and costs. These risks have been and continue to be addressed through multiple means, including: the direct contracting of the environmental assessment by NSF; the hiring of two national firms by NEON, Inc. for engineering and permitting; the identification of alternative sites if the primary sites are determined to have significant

risk; and the allocation of two full-time equivalents (FTE) by the U.S. Forest Service to assist with environmental compliance issues on Forest Service lands.

Geospatial Data Acquisition: A potential risk is the long-term availability of satellite (e.g., LANDSAT and MODIS) borne sensors. This risk is mitigated through a partnership with the USGS Earth Resources Observation and Science (EROS) Data Center, which has the federal responsibility for curation and management of LANDSAT and MODIS images. This partnership allows NEON to have alternative satellite sensor sources to purchase images (e.g., SPOT - France, AWIFS – India, Terra and Aqua – U.S.). Experienced flight design engineers were contracted by NEON, Inc. to provide the baseline operations plans, aircraft analysis, and assessment of commercial companies that could potentially support NEON flight operations, and experienced research aircraft pilots served on the design team.

Future Operations Costs

NEON is the first research observatory that when complete, will maintain and operate in-situ instrumentation and conduct biological sampling in twenty domains (106 locations); three airborne observatories; a central operating facility; and a cyberinfrastructure center. Support will be provided to monitor the sensors, and receive, process, and archive the data from all measurement systems. NEON operations include significant labor costs due to the labor-intensive processes required for biological sampling and data collection. NEON is reliant on sensors and cyberinfrastructure that have a defined lifecycle, so operations costs include scheduled replacement and refreshing of sensor, instrumentation, and cyberinfrastructure technology. Operations are planned to ramp up commensurate with commissioned sites.

A three year initial award for operations and maintenance began in September 2014 to allow NEON to explore opportunities for schedule and cost efficiencies and provide the basis for funding full Observatory operations for the outyears. For FY 2017 – FY 2021, the costs are held constant at the projected operations ceiling reviewed at both PDR and FDR, pending results of the three year award.

ORGANIZATIONAL EXCELLENCE

NSF's Strategic Plan for 2014-2018, *Investing in Science, Engineering, and Education for the Nation's Future,*[1] which was released in March 2014, includes "Organizational Excellence" as an NSF core value and defines it as "investing the resources entrusted to us optimally and efficiently, and realizing the full potential of our people in managing a capable, motivated, inclusive, and positive work environment" – and directly links it to the new strategic goal of "Excel as a Federal Science Agency."

The portfolio of activities included in Organizational Excellence is internally focused and addresses the agency's operations and administrative functions, which underpin NSF's programmatic activities. The activities in the Organizational Excellence portfolio are critical to the accomplishment of the agency's other two strategic goals, "Transform the Frontiers of Science and Engineering" and "Stimulate Innovation and Address Societal Needs through Research and Education."

Through the Strategic Reviews of the objectives presented in the Strategic Plan, NSF identified opportunities for action or improvement. A number of these opportunities can be found within the portfolio of Organizational Excellence activities, and proposals to implement the opportunities are included in the FY 2016 Request.

Organizational Excellence FY 2016 Request
(Dollars in Millions)

FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Percent
$439.19	$465.42	$500.79	$35.37	7.6%

NSF's FY 2016 Request for Organizational Excellence of $500.79 million is $35.37 million, or 7.6 percent, above the FY 2015 Estimate of $465.42 million.

This discussion provides an overview of the various activities that are included in the Organizational Excellence portfolio. The table on the following page shows the major components of Organizational Excellence: Human Capital, Travel, Information Technology (IT), Administrative Support, NSF Headquarters Relocation, and support for the National Science Board (NSB) and the Office of Inspector General (OIG). This table also shows the funding sources for the major components/activities, as several are funded through more than one appropriation. Also included in this overview are NSF workforce data and information on the E-Government Initiatives to which the agency contributes.

Underlying the Request level is NSF's ongoing commitment to increase agency efficiency while constraining administrative costs. NSF has made significant progress toward reducing certain administrative costs by identifying and implementing efficiencies, prioritizing work, eliminating or scaling back the scope of some activities, and by exploring new ways of getting the job done. For example, FY 2014 travel costs were reduced over 25 percent below the FY 2010 baseline, as the agency has prioritized travel requirements and continued the use of virtual peer review panels.

In addition, in FY 2016 NSF provides ongoing support for three management improvement efforts. The Public Access Initiative will make the results of NSF-funded research available to the greatest extent possible, to foster progress in scientific research by reducing barriers to communications. The goal of the

[1] www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf14043

Proposal Management Efficiencies activity is to improve the agency's systems and processes for managing the merit review of proposals and the goal of the Evaluation and Assessment Capability activity is to build the agency's capability to operate from a basis of evidence in policy decisions. More information on Proposal Management Efficiencies and the Evaluation and Assessment Capability can be found in the NSF-Wide Investments chapter.

Organizational Excellence
(Dollars in Millions)

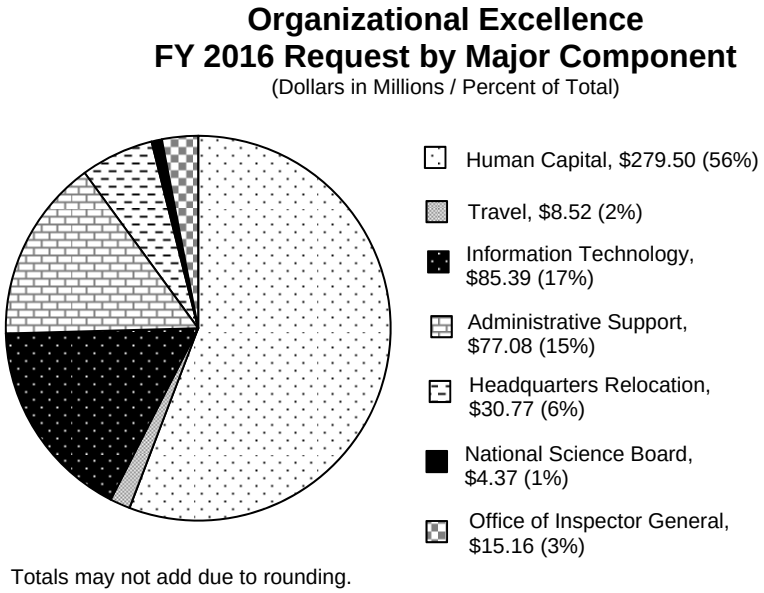
	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Change over FY 2015 Estimate Percent	Funding Source and Sub-section/Page Where Details are Available
Human Capital	$253.02	$265.48	$279.50	$14.02	5.3%	
Personnel Compensation & Benefits	202.88	214.44	224.35	9.91	4.6%	AOAM - 2
Management of Human Capital	10.69	8.11	10.00	1.89	23.3%	AOAM - 3
IPA Appointments	39.45	42.93	45.15	2.22	5.2%	R&RA/EHR - 1
Compensation	35.62	38.61	40.56	1.95	5.1%	R&RA/EHR - 2
Lost Consultant & Per Diem	3.83	4.32	4.59	0.27	6.3%	R&RA/EHR - 2
Travel	$7.61	$8.54	$8.52	-$0.02	-0.2%	
NSF Staff	4.83	5.45	5.45	-	-	AOAM - 4
IPA Appointments	2.78	3.09	3.07	-0.02	-0.5%	R&RA/EHR - 1
Information Technology (IT)	$85.21	$86.49	$85.39	-$1.10	-1.3%	
Agency Operations IT	18.04	22.00	21.99	-0.01	-0.0%	AOAM - 5
Administrative Applications Services and Support	6.80	5.37	5.11	-0.26	-4.8%	AOAM - 5
Associated IT Operations and Infrastructure	9.48	13.84	13.84	-	-	AOAM - 5
Related Security and Privacy Services	1.76	2.79	3.03	0.24	8.6%	AOAM - 5
Program Related Technology (PRT)	67.17	64.49	63.40	-1.09	-1.7%	R&RA/EHR - 2
Mission-Related Applications Services	48.70	47.50	45.99	-1.51	-3.2%	R&RA/EHR - 3
Associated IT Operations and Infrastructure	15.51	14.01	14.44	0.43	3.1%	R&RA/EHR - 4
Related Security and Privacy Services	2.96	2.98	2.98	-	-	R&RA/EHR - 4
Administrative Support	$60.87	$69.31	$77.08	$7.77	11.2%	
Space Rental	31.20	33.91	34.17	0.26	0.8%	AOAM - 6
Operating Expenses	8.51	13.82	15.04	1.22	8.9%	AOAM - 7
Building and Administrative Services	15.41	10.46	13.07	2.61	24.9%	AOAM - 8
Other Program Related Administration	5.75	11.12	14.80	3.68	33.1%	R&RA/EHR - 5
Major NSF-Wide Priorities	1.10	5.80	9.16	3.36	57.9%	
Evaluation and Assessment Capability	*0.80*	*5.50*	*8.86*	*3.36*	*61.1%*	R&RA/EHR - 5
Proposal Management Efficiencies	*0.30*	*0.30*	*0.30*	-	-	R&RA/EHR - 5
E-Government Initiatives	1.04	1.01	1.01	-	-	R&RA/EHR - 5
General Planning and Evaluation Activities	3.61	4.31	4.63	0.32	7.4%	R&RA/EHR - 5
NSF Headquarters Relocation	$14.39	$16.81	$30.77	$13.96	83.0%	AOAM - 10
National Science Board (NSB)	$4.25	$4.37	$4.37	-	-	NSB - 1
Office of Inspector General (OIG)	$13.84	$14.43	$15.16	$0.73	5.1%	OIG - 1
Total, Organizational Excellence	**$439.19**	**$465.42**	**$500.79**	**$35.37**	**7.6%**	

Totals may not add due to rounding.

AOAM: Agency Operations and Award Management; R&RA: Research and Related Activities; EHR: Education and Human Resources; IPA: Intergovernmental Personnel Act

Organizational Excellence by Major Component

The chart on the right shows the seven major components of Organizational Excellence and their percentage of the total at the FY 2016 Request level.



Totals may not add due to rounding.

1. Human Capital: Support for NSF's human capital activities is the largest component of Organizational Excellence, accounting for 56 percent of the total portfolio. The Human Capital component includes personnel compensation and benefits of NSF's federal employees as well as support for NSF's temporary employees hired through authority provided by the Intergovernmental Personnel Act, known as "IPAs". NSF's federal employee FTE (full-time equivalents) are funded through the Agency Operations and Award Management (AOAM) account while IPAs are funded through two programmatic accounts — Research and Related Activities (R&RA) or Education and Human Resources (EHR).

The Human Capital component also includes support for the Management of Human Capital, which includes:

- Human resources systems accessed through shared service providers, including the Federal Personnel Payroll System, the time and attendance system (WebTA), eRecruit capabilities using USAJobs, and security investigations of incoming staff.
- Operational activities including recruiting, hiring, and on-boarding of permanent and rotating staff, as well as processing support for pay and benefits and awards.
- Workplace and career-life balance support for employees including the Health Unit, the Employee Assistance Program, and child care subsidy.
- Contracts that support training and development programs, on-line training capabilities, networking activities including the NSF mentoring program, executive and supervisory training and program management training.

The FY 2016 Request amount for Human Capital is $279.50 million, an increase of $14.02 million, or 5.3 percent, over the FY 2015 Estimate of $265.48 million. FTE utilization increases 15 FTE or 1.1 percent above the FY 2015 Estimate level of 1,355. IPA FTE utilization increases by 5 over the FY 2015 Estimate to a total of 196. Detailed information about Human Capital activities can be found in the AOAM chapter. Detailed information about IPAs can be found in the R&RA/EHR chapter.

<u>NSF Workforce:</u>

The table below shows the agency's total workforce for FY 2016.

- At the FY 2016 Request, the number of NSF's federal FTE increases by 17 over the FY 2015 Estimate to a level of 1,448. The number of IPAs increases by five to 196.

- The staffing profile shows that a small but significant percentage of the NSF workforce consists of temporary employees hired through authority provided by the Intergovernmental Personnel Act. IPAs do not count as federal FTEs.
- A number of visiting staff – roughly 40 people annually – are employed through NSF's own Visiting Scientist, Engineer, and Educator Program (VSEE). VSEEs count as federal FTE and are included in the Federal Employee FTE total. The use of IPAs and VSEEs, commonly referred to as rotators, has been a defining characteristic of NSF since its inception in 1950, as it gives NSF a direct connection to the researchers and educators working at the frontiers of science and engineering.

A discussion of NSF FTE allocation and usage is included in the Personnel Compensation and Benefits section, beginning on page AOAM-1. A more detailed discussion about IPAs is included in the R&RA/EHR chapter. The OIG, NSB, and Arctic Research Commission chapters include a discussion of their respective workforce issues.

NSF Workforce

Full-Time Equivalents (FTE)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Change over FY 2015 Estimate Percent
AOAM FTE Allocation					
Regular	*1,310*	*1,310*	*1,325*	*15*	*1.1%*
Students[1]	*42*	*42*	*42*	-	-
Subtotal, AOAM FTE Allocation	*1,352*	*1,352*	*1,367*	*15*	*1.1%*
AOAM FTE Usage (Actual/Projected)					
Regular	1,269	1,310	1,325	15	1.1%
Students[1]	32	42	42	-	-
Subtotal, AOAM FTE	1,301	1,352	1,367	15	1.1%
Office of the Inspector General	68	73	76	3	4.1%
Regular	67	73	75	2	2.7%
Student[1]	1	-	1	1	N/A
National Science Board	19	19	19	-	-
Arctic Research Commission	3	4	3	-1	-25.0%
Total, Federal Employees (FTE)	1,391	1,448	1,465	17	1.2%
IPAs (FTE)	177	191	196	5	2.6%
Detailees to NSF	3	3	3	-	-
Contractors (est.)	449	449	449	-	-
Total, Workforce	**2,020**	**2,091**	**2,113**	**22**	**1.1%**

Totals may not add due to rounding.

[1] Includes Pathways students. The Pathways program was established by Executive Order 13562, *Recruiting and Hiring Students and Recent Graduates*. The internship program offers part- or full-time paid internships in federal agencies to qualifying students (students in high schools, community colleges, four-year colleges, trade schools, career and technical education programs, and other qualifying technical education programs).

2. Travel: Support for NSF staff and IPA travel accounts for two percent of NSF's Organization Excellence portfolio. For FY 2016, the request for staff and IPA travel is $8.52 million, $20,000 below the FY 2015 Estimate of $8.54 million. Staff travel accounts for about 64 percent of this total; a request of $5.45 million in FY 2016. Travel for IPA appointments, which is supported by programmatic funds from the R&RA and EHR accounts, is $3.07 million. For more detailed information about NSF staff and IPA travel funding, see pages AOAM-4 and R&RA/EHR-1.

In FY 2016, NSF will meet its travel funding reduction targets per OMB Memorandum M-12-12, *Promoting Efficient Spending to Support Agency Operations*. Although savings have been achieved across most travel categories through a revision in the agency's travel policy, the key driver has been the reduction of travel costs associated with merit review panels, which are supported by programmatic funds in the R&RA and EHR accounts. AOAM funded travel accounts for approximately 31.5 percent of NSF's FY 2016 total travel cost.

3. Information Technology (IT): IT investments are the second largest component of Organizational Excellence, accounting for 17 percent.

- Agency operations IT investments are funded through the AOAM account and support the agency's basic administrative operations including: (1) Administrative Applications Services and Support, such as NSF's human resources management systems, a portion (30 percent) of NSF's financial system (iTRAK), and routine maintenance of collaboration services such as SharePoint and the NSF website; (2) Associated IT Operations and Infrastructure, such as office automation activities, including its network and telecommunications requirements (e.g., NSF's data center, network, hosting, phone, email, and remote access services); NSF's call center and customer care services; and (3) Related Security and Privacy Services for administrative systems in alignment with federal cybersecurity priorities. More detailed information about NSF's agency operations IT investments can be found beginning on page AOAM-5. Agency operations IT investments account for about 26 percent of NSF's total IT investment.
- Program Related Technology (PRT) investments support NSF's programmatic activities and associated services and are funded through the R&RA and EHR accounts. PRT investments support the merit review process, including pre-award planning and activities; receipt of proposals; processing proposals; reviewing proposals; award decisions, documentation, and notification; funding awards; post-award oversight; dissemination of award results; and award close-out. Mission-related IT applications and services include investments in Research.gov, eJacket, FastLane, a portion (70 percent) of iTRAK, and the associated security and privacy requirements for PRT-funded systems. PRT investments account for 74 percent of NSF's IT investments, and are discussed in more detail beginning on page R&RA/EHR-2.

The following table shows NSF's IT funding by appropriation. For FY 2016, IT investments total $85.39 million, a $1.10 million, or 1.3 percent, decrease below the FY 2015 Estimate of $86.49 million.

IT Investments by Appropriation

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Change over FY 2015 Estimate Percent
Agency Operations & Award Management (AOAM)	$18.04	$22.00	$21.99	-$0.01	-
Program Related Technology (PRT)	$67.17	$64.49	$63.40	-$1.09	-1.7%
R&RA	*59.07*	*56.10*	*55.16*	*-0.94*	*-1.7%*
EHR	*8.10*	*8.38*	*8.24*	*-0.14*	*-1.7%*
Total	**$85.21**	**$86.48**	**$85.39**	**-$1.09**	**-1.3%**

Totals may not add due to rounding.

4. Administrative Support: Funding for Administrative Support accounts for 15 percent of the total Organizational Excellence portfolio. FY 2016 funding for Administrative Support is $77.08 million, a $7.77 million (11.2 percent) increase over the FY 2015 Estimate of $69.31 million. The activities that comprise Administrative Support are detailed below.

- The largest component of Administrative Support is Space Rental at $34.17 million – an increase of $260,000 over the FY 2015 Estimate of $33.91 million. Space rental includes services provided by the General Services Administration related to rent utilities, taxes, and services provided by the Federal Protective Service for security. NSF currently occupies 665,000 square feet of space primarily in two adjoining, leased office buildings located in Arlington, Virginia. The current leases for the two buildings have been replaced by interim occupancy agreements that extend occupancy until the upcoming move of NSF to Alexandria, Virginia. More detailed information about Space Rental can be found on page AOAM-6.
- Operating Expenses include funding for supplies and equipment, training, communications devices, and printing, which are necessary for the accomplishment of NSF's mission. In addition, various financial and award management and leadership activities are supported, such as post-award monitoring; contract close-out activities; large facility oversight; improper payments, financial statement, and internal controls reporting; CEOSE (Committee on Equal Opportunities in Science and Engineering) activities; and the Enterprise Information System. A detailed discussion about Operating Expenses can be found beginning on page AOAM-7.
- Building and Administrative Services (formerly Other Infrastructure) includes administrative contracts that support NSF's facilities and business operations such as the mail center, loading dock, supply and warehouse management; conference room and merit review panel support including audiovisual and virtual meeting support; printing, digital scanning and imaging; travel management support; NSF intranet operations and maintenance; and the visitor information center. Funding for administrative services, equipment, and supplies support NSF's infrastructure and include activities such as security system maintenance, ID issuance, public announcement system maintenance, the NSF Alert System, continuity of operations support services, and Federal Register notices for panels and advisory committees. Funding for government goods and services include support of core business activities such as records storage and relocation administration. A detailed discussion of these activities can be found beginning on page AOAM-8.
- Other Program Related Administration (PRA) funds support general Planning and Evaluation activities, which are agency-wide efforts such as the verification and validation of performance information; the Waterman Award administrative costs; certain IPA costs; some American Association for the Advancement of Science (AAAS) fellowships and internships, and E-Government efforts. Ongoing support also is provided for two management improvement efforts—Evaluation and Assessment Capability (EAC) and Proposal Management Efficiencies (PME). Support for EAC, $8.86 million, has the largest increase within Administrative Support at 61.1 percent or $3.36 million over the FY 2015 Estimate of $5.50 million. Detailed information about both EAC and PME can be found in the NSF-Wide Investments chapter. A detailed discussion about Other PRA can be found beginning on page R&RA/EHR-5.

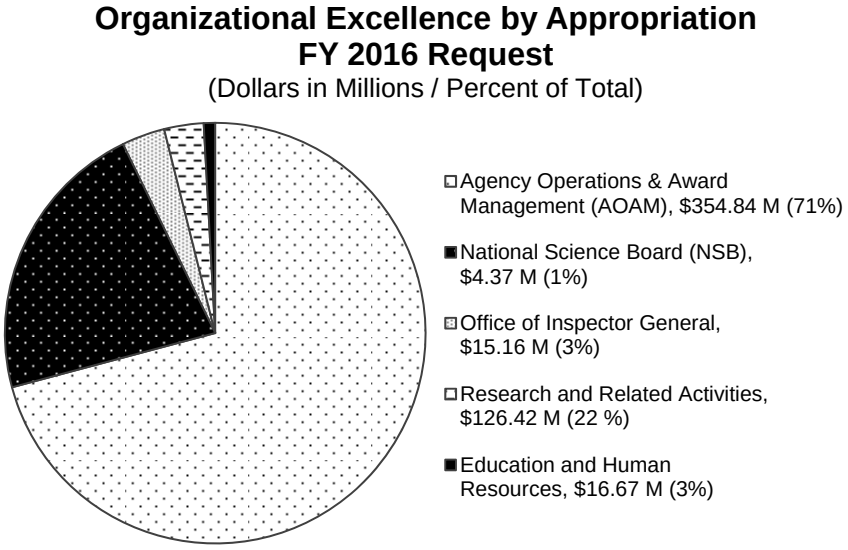
5. NSF Headquarters (HQ) Relocation: In June 2013, GSA awarded a 15-year lease for NSF's new headquarters to be located in Alexandria, Virginia. The FY 2016 Request provides support for HQ Relocation program management costs, including project administration and management, design and construction oversight, and coordination activities. The FY 2016 Request of $30.77 million represents an increase of $13.96 million above the FY 2015 Estimate. More detailed information about NSF HQ Relocation can be found beginning on page AOAM-10.

6. National Science Board (NSB): The staffing and operations of the NSB office are supported through a separate NSB appropriation. Details about the NSB FY 2016 Request can be found in the NSB chapter.

7. Office of Inspector General (OIG): The staffing and operations of the OIG are supported through a separate OIG appropriation. Details about the OIG FY 2016 Request can be found in the OIG chapter.

Organization Excellence by Appropriation

Organizational Excellence funding by account for the FY 2016 Request is shown in the chart on the right and in the table below



Totals may not add due to rounding.

- 71 percent of Organizational Excellence is funded through AOAM.
- The R&RA and EHR accounts fund program support costs – $126.42 million (22 percent) through the R&RA account and $16.67 million (three percent) through the EHR account.
- The activities of the OIG and NSB are each funded by separate appropriation accounts. The FY 2016 Request for the OIG of $15.16 million accounts for three percent of the Organizational Excellence portfolio. The NSB FY 2016 Request of $4.37 million accounts for one percent of the Organizational Excellence portfolio.

Organizational Excellence by Appropriation

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Change over FY 2015 Estimate Percent
Agency Operations & Award Management (AOAM)	$305.95	$325.00	$354.84	$29.84	9.2%
National Science Board (NSB)	4.25	4.37	4.37	-	-
Office of Inspector General	13.84	14.43	15.16	0.73	5.1%
Program Support:	$115.14	$121.62	$126.42	$4.80	3.9%
Research and Related Activities	*100.70*	*105.91*	*109.75*	*3.84*	*3.6%*
Education and Human Resources	*14.44*	*15.71*	*16.67*	*0.96*	*6.1%*
Total	**$439.19**	**$465.42**	**$500.79**	**$35.37**	**7.6%**

Total may not add due to rounding.

NSF FY 2015 and FY 2016 Funding for E-Government Initiatives

The tables below show NSF's contributions and service fees for various E-Government initiatives.

NSF FY 2015 Estimate Funding for E-Government Initiatives

	FY 2015			Appropriations Account		
Initiative	Agency Contributions	Agency Svc. Fees	NSF Total	AOAM	R&RA	EHR
Grants.gov	$450,354	-	$450,354	-	$391,808	$58,546
E-Travel	-	184,467	184,467	184,467		
Geospatial LoB	25,000	-	25,000	-	21,750	3,250
E-Training	-	370,000	370,000	370,000	-	-
E-Rulemaking	-	13,694	13,694	13,694	-	-
Recruitment One-Stop (USA Jobs)	-	7,537	7,537	7,537	-	-
E-HRI	-	24,634	24,634	24,634	-	-
Integrated Acquisition Environment (IAE) including Loans and Grants	-	253,544	253,544	18,079	204,855	30,610
Human Resources Management LoB	65,217	-	65,217	-	56,739	8,478
Financial Management LoB	132,262	-	132,262	-	115,068	17,194
Budget Formulation/Execution LoB	105,000	-	105,000	-	91,350	13,650
Performance Management LoB	-	-	-	-	-	-
E-Payroll (incl. Shared Services)	-	314,640	314,640	314,640	-	-
Total	**$777,833**	**$1,168,516**	**$1,946,349**	**$933,051**	**$881,570**	**$131,728**

LoB: Line of Business; Totals may not add due to rounding.

NSF FY 2016 Request Funding for E-Government Initiatives

	FY 2016			Appropriations Account		
Initiative	Agency Contributions	Agency Svc. Fees	NSF Total	AOAM	R&RA	EHR
Grants.gov	$435,517	-	$435,517	-	$378,900	$56,617
E-Travel	-	184,467	184,467	184,467	-	-
Geospatial LoB	25,000	-	25,000	-	21,750	3,250
E-Training	-	370,000	370,000	370,000	-	-
E-Rulemaking	-	10,374	10,374	13,694	-	-
Recruitment One-Stop (USA Jobs)	-	8,342	8,342	7,537	-	-
E-HRI	-	24,634	24,634	24,634	-	-
Integrated Acquisition Environment (IAE) including Loans and Grants	-	253,544	253,544	18,079	204,855	30,610
Human Resources Management LoB	65,217	-	65,217	-	56,739	8,478
Financial Management LoB	139,094	-	139,094	-	121,012	18,082
Budget Formulation/Execution LoB	105,000	-	105,000	-	91,350	13,650
Performance Management LoB	-	-	-	-	-	-
E-Payroll (incl. Shared Services)	-	314,640	314,640	314,640	-	-
Total	**$769,828**	**$1,166,001**	**$1,935,829**	**$933,051**	**$874,605**	**$130,688**

LoB: Line of Business; Totals may not add due to rounding.

PROGRAM ACCOUNTS: R&RA and EHR — $126,420,000 +$4,800,000 / 3.9%

Funding from program accounts (R&RA and EHR) covers about 25 percent of the total Organizational Excellence portfolio. There are two activities that comprise program-funded Organizational Excellence: Intergovernmental Personnel Act (IPA) costs and Program Related Administration.

Summary of R&RA- and EHR-Funded Organizational Excellence

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Change over FY 2015 Estimate Percent
IPA Costs	$42.23	$46.01	$48.22	$2.21	4.8%
Program Related Administration	72.91	75.61	78.20	2.59	3.4%
Program Related Technology	*67.17*	*64.49*	*63.40*	*-1.09*	*-1.7%*
Other Program Related Administration	*5.75*	*11.12*	*14.80*	*3.68*	*33.1%*
Total, R&RA and EHR Funded Organizational Excellence	**$115.14**	**$121.62**	**$126.42**	**$4.80**	**3.9%**

Totals may not add due to rounding.

Intergovernmental Personnel Act (IPA) Costs

IPA Costs by Appropriation

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Change over FY 2015 Estimate Percent
IPA FTE Utilization[1]	177	191	196	5	2.6%
R&RA					
IPA Compensation	$31.39	$34.01	$35.96	$1.95	5.7%
IPA Lost Consultant & Per Diem	3.29	3.47	3.74	0.27	7.8%
IPA Travel	2.47	2.66	2.64	-0.02	-0.6%
Subtotal, R&RA Costs	$37.15	$40.13	$42.34	$2.21	5.5%
EHR					
IPA Compensation	4.23	4.60	4.60	-	-
IPA Lost Consultant & Per Diem	0.54	0.85	0.85	-	-
IPA Travel	0.31	0.43	0.43	-	-
Subtotal, EHR Costs	$5.08	$5.88	$5.88	-	-
Total, IPA Costs	**$42.23**	**$46.01**	**$48.22**	**$2.21**	**4.8%**

Totals may not add due to rounding.

[1] Includes five IPAs in FY 2014 and six IPAs in FY 2015 and FY 2016 in staff offices (BFA, OIRM, and OLPA) funded by Other Program Administration and included in General Program and Evaluation (P&E) activities.

A portion of NSF's workforce consists of temporary staff hired through the Intergovernmental Personnel Act (IPA) authority. IPAs remain employees of their home institution while serving alongside NSF employees during their temporary appointment. They are not paid directly by NSF and are not subject to federal pay, benefits, or other limitations. NSF reimburses the home institution without overhead using the traditional grant mechanism. IPAs are eligible to receive relocation expenses, or a per diem allowance

in lieu of relocation, and reimbursement for income foregone because of their assignment at NSF (i.e., lost consulting fees).

The agency uses IPA (or rotating) science and engineering staff to help ensure that the Foundation's funding decisions are based on the best input from the field and reflect fresh ideas and creativity. The expertise provided by these IPAs is essential to help shape the NSF research portfolio and support transformational advances across the frontiers of all fields of science, engineering, and education.

The FY 2016 Request funding for IPA costs, $48.22 million, represents an increase of $2.21 million above the FY 2015 Estimate of $46.01 million. At this level, IPA usage increases by five IPA FTE to a total of 196 IPA FTE and raises costs within the Research and Related Activities (R&RA) account associated with IPA compensation to $35.96 million and Lost Consultant and Per Diem to $3.74 million. IPA Travel decreases $20,000 below the FY 2015 Estimate, in keeping with the agency's overall travel funding targets.

Program Related Administration

Program Related Administration (PRA) includes two categories of activities that support NSF's strategic goal *Excel as a Federal Science Agency* and that are directly funded from NSF's program accounts.

- Program Related Technology (PRT)
- Other Program Related Administration (Other PRA)

Program Related Administration

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Change over FY 2015 Estimate Percent
Program Related Technology	$67.17	$64.49	$63.40	-$1.09	-1.7%
Other Program Related Administration	5.75	11.12	14.80	3.68	33.1%
Total, Program Related Administration	**$72.91**	**$75.61**	**$78.20**	**$2.59**	**3.4%**

Totals may not add due to rounding.

Program Related Technology (-$1.09 million, to a total of $63.40 million)

NSF's FY 2016 total information technology (IT) investment is $85.39 million. Funding for the IT investment is split between the Research and Related Activities (R&RA), Education and Human Resources (EHR), and the Agency Operations and Award Management (AOAM) accounts. PRT activities relate directly to NSF's programmatic investments and are the portion of NSF's IT investment funded through the R&RA and EHR accounts. NSF's FY 2016 Request funding for PRT is $63.40 million, a decrease of $1.09 million below the FY 2015 Estimate. The remaining $21.99 million IT investment is AOAM funded and is discussed in the AOAM section.

Program Related Technology Investments
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Percent
Mission-Related Applications and Services	$48.70	$47.50	$45.99	-$1.51	-3.2%
Associated IT Operations and Infrastructure	15.51	14.01	14.44	0.43	3.1%
Related Security and Privacy Services	2.96	2.98	2.98	-	-
Total, Program Related Technology	**$67.17**	**$64.49**	**$63.40**	**-$1.09**	**-1.7%**

Totals may not add due to rounding.

Funding for PRT underpins NSF's role in supporting fundamental research across all fields and levels of science and engineering. NSF accomplishes this principally by issuing grants to fund specific research proposals that have been judged the most promising through the merit review process. Each stage in the NSF proposal and award management process is managed electronically. With this single mission focus, PRT investments are critical to supporting science and engineering research and education activities within the Foundation.

For FY 2016, NSF's information technology priorities for PRT are:

- Continue modernization of systems that support the merit review process. Focus will be on systems that support the management of proposals, reviews, and reviewers. For more information, see the Proposal Management Efficiencies narrative in the NSF-Wide Priorities chapter.
- Continue to work toward a federated system to manage results of NSF-funded research that integrates external (repository) and internal administrative systems with minimal additional burden to NSF awardees and staff. This federated approach will eventually allow researchers to make their results available through submission to multiple acceptable repositories while reporting centrally to NSF and providing for long term preservation.
- Support the second full year of operation of iTRAK, the Foundation's financial management system.
- Support the upcoming move of NSF's headquarters.

Mission-Related Applications and Services (-$1.51 million, to a total of $45.99 million)
Investments in this category fund the applications and services that support the merit review process, including pre-proposal planning and activities; receipt of proposals; processing proposals; reviewing proposals; award decisions, documentation, and notification; funding awards; post-award oversight; dissemination of award results; and award close-out. Mission-related applications and services include investments such as iTRAK, Research.gov, eJacket, and FastLane.

- The total investment for iTRAK is $5.70 million. Seventy percent of this request will be funded by PRT and 30 percent will be funded by AOAM. In FY 2016, the PRT portion of the iTRAK request is $3.99 million. This increase of $915,000 above the FY 2015 Estimate will support the ongoing operations and maintenance of the new system.
- Funding for legacy mission applications is $28.45 million, $550,000 below the FY 2015 Estimate. The decrease reflects the Foundation's capacity to modernize and maintain applications and services while simultaneously preparing for the move to a new headquarters. Legacy mission applications, including FastLane and eJacket, support the grants management life cycle. These applications are used by NSF staff, principal investigators, reviewers, and awardee institutions. This investment will be utilized for the following activities:
    - PRT funding for NSF's Public Access Initiative is $3.0 million, representing an increase of $500,000 over the FY 2015 Estimate. This investment will be used to increase public access to the results of NSF-funded research. Specifically, the requested funds will be used to initiate

planning activities to expand NSF's federated model for public access to additional repositories and to enhance the services provided to users of NSF's public access capability.
  - $5.72 million for eJacket and $4.91 million for FastLane provides the necessary funds for operations and maintenance of these mission support systems. These levels are not changed from the FY 2015 Estimate.
  - Other mission-related applications decrease $1.05 million below the FY 2015 Estimate to a total of $14.82 million. This funding level reflects the Foundation's need to defer enhancements of other mission-related applications, to allow for planning and preparing for the move to the new NSF headquarters.
- $2.50 million in FY 2016 will support operations, maintenance, and ongoing enhancement of the enterprise data warehouse. This funding level is consistent with the FY 2015 Estimate. A data warehouse at the enterprise level avoids costs associated with implementing separate data warehouses or data marts for individual IT investments, enables agency-wide business intelligence, and achieves administrative efficiencies by centralizing and streamlining access to NSF data.
- Research.gov is a community driven solution to modernize NSF's legacy grants management applications by facilitating seamless access to key information and services to the science, engineering, research and education communities and the public in one location.[1] Research.gov is used by grantees to report annually on the progress and results of NSF-funded projects, as well as to view balances on awards, submit financial requests, and report program income. Researchers and institutions are also able to login to Research.gov and access legacy grants management services in one location. The Research.gov investment in FY 2016 is $10.30 million, which represents a decrease of $1.88 million below the FY 2015 Estimate. This level reflects the Foundation's capacity for modernization of Research.gov while simultaneously preparing for the move of NSF headquarters.
- Consistent with the FY 2015 Estimate, $754,000 is provided for enterprise architecture and planning.

Associated IT Operations and Infrastructure (+$430,000, to a total of $14.44 million)

Investments in this category provide basic operations and maintenance funding for NSF infrastructure, network, and telecommunications requirements. Network services include NSF's primary network for NSF staff, external network for NSF visitors, and connection to Internet2 for virtual panel support. Additionally, this category includes NSF's call center and customer care services. NSF provides customer care support for internal users (NSF staff) and external users (the research community including institutions, principal investigators, reviewers, and other NSF visitors) 14 hours per day, five days per week.

The requested $430,000 increase will allow NSF to continue to implement cyber-infrastructure at the new NSF headquarters while maintaining a parallel infrastructure at the current NSF headquarters.

Related Security and Privacy Services (+ zero, to a total of $2.98 million)

Funding in this area is not changed from the FY 2015 Estimate. Investments in this category include automated configuration management tools that manage security patches and provide proactive protection from viruses, spyware, and other threats. This includes the relative portion of NSF's network security, application security, security control testing and tools, automated vulnerability assessment tools, and remediation and intrusion detection services related to mission-support applications and services.

[1] www.research.gov/

Other Program Related Administration (+$3.68 million to a total of $14.80 million)

In FY 2016, NSF's Other PRA includes funding for four Foundation-wide activities:

- Capability building and enhancements to the Foundation's evaluation initiative;
- Efforts to improve NSF's merit review process;
- NSF support for federal E-Government initiatives that are mission-related; and
- General planning and evaluation activities that are Foundation-wide.

Other Program Related Administration

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Change over FY 2015 Estimate Percent
Major NSF-wide Investments					
Evaluation and Assessment Capability	$0.80	$5.50	$8.86	$3.36	61.1%
Proposal Management Efficiencies	0.30	0.30	0.30	-	-
Other					
E-Government Initiatives	1.04	1.01	1.01	-	-
General Planning and Evaluation Activities	3.61	4.31	4.63	0.32	7.4%
Total, Other Program Related	**$5.75**	**$11.12**	**$14.80**	**$3.68**	**33.1%**

Totals may not add due to rounding.

Evaluation and Assessment Capability (EAC), (+$3.36 million, to a total of $8.86 million): In FY 2016, Other PRA funding of $8.86 million will enable further development of the Foundation's Evaluation and Assessment Capability. Activities supported include portfolio analysis tool development, initiation of high-impact evaluations for cross-cutting high visibility programs, coordinating with the National Center for Science and Engineering Statistics (NCSES) on the design of data collection instruments and methodological considerations for longitudinal data collections, and developing a coordinated evaluation framework for the agency. More detailed information for EAC can be found within the NSF-wide Priorities chapter.

Proposal Management Efficiencies, (no change for a total of $300,000): FY 2016 Other Program Related Administration funding of $300,000 will continue to support assessment activities in order to determine the impacts of NSF's investments in improving the merit review process and to identify further potential to enhance the process. Detailed information can be found in the Proposal Management Efficiencies narrative in the NSF-Wide Priorities chapter.

E-Government Initiatives (no change for a total of $1.01 million): In FY 2016, funding for NSF program-supported and mission-related E-Government initiatives is equal to the FY 2015 Estimate. This funding level is consistent with funding requirements identified by the respective managing partner organizations.

General Planning and Evaluation Activities (P&E) (+$320,000, to a total of $4.63 million): FY 2016 Other Program Related Administration funding for P&E activities will be $4.63 million to support activities such as the verification and validation of performance information; the Waterman Award administrative costs; contributions to the General Services Administration in support of the interagency management councils, and AAAS fellowships and internships. The FY 2016 funding estimate is based on the level of activities and projects anticipated in FY 2016.

AGENCY OPERATIONS AND AWARD MANAGEMENT

$354,840,000
+$29,840,000 / 9.2%

Summary of Agency Operations and Award Management
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Change over FY 2015 Estimate Percent
Personnel Compensation and Benefits	$202.88	$214.44	$224.35	$9.91	4.6%
Management of Human Capital	10.69	8.11	10.00	1.89	23.3%
Travel	4.83	5.45	5.45	-	-
Information Technology	18.04	22.00	21.99	-0.01	-0.0%
Space Rental	31.20	33.91	34.17	0.26	0.8%
Operating Expenses	8.51	13.82	15.04	1.22	8.8%
Building and Administrative Services	15.41	10.46	13.07	2.61	25.0%
NSF HQ Relocation	14.39	16.81	30.77	13.96	83.0%
Total, AOAM	**$305.95**	**$325.00**	**$354.84**	**$29.84**	**9.2%**

Totals may not add due to rounding.

Investments in the Agency Operations and Award Management (AOAM) account advance NSF's Excel as a Federal Science Agency strategic goal and continue to be an NSF priority. This activity provides the fundamental framework through which the Foundation's science and engineering research and education programs are administered. AOAM's priorities are framed by two strategic objectives:

- Use effective business methods and innovative solutions to achieve excellence in accomplishing the agency's mission; and
- Build an increasingly diverse, engaged, and high-performing NSF workforce by fostering excellence in recruitment, training, leadership, and management of human capital.

Personnel Compensation and Benefits (PC&B) (+$9.91 million, to a total of $224.35 million)

AOAM NSF Workforce
(Full-Time Equivalent (FTE) and Other Staff)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Change over FY 2015 Estimate Percent
NSF AOAM FTE Allocation					
NSF AOAM -- Regular	1,310	1,310	1,325	15	1.1%
NSF AOAM -- Pathways Intern	42	42	42	-	-
Subtotal, FTE Allocation	1,352	1,352	1,367	15	1.1%
NSF AOAM FTE Usage					
NSF AOAM -- Regular	1,269	1,310	1,325	15	1.1%
NSF AOAM -- Pathways Intern	32	42	42	-	-
Subtotal, FTE Usage	1,301	1,352	1,367	15	1.1%
Detailees to NSF	3	3	3	-	-
Total, Workforce (Usage)	**1,304**	**1,355**	**1,370**	**15**	**1.1%**

Totals may not add due to rounding.

Personnel Compensation & Benefits

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Change over FY 2015 Estimate Percent
Regular FTE Usage (projected)	1,269	1,310	1,325	15	1.1%
Student FTE Usage (projected)	*42*	*42*	*42*	-	-
Regular FTE Base Salary	$154.32	$160.21	$166.81	$6.60	4.1%
Student Salary	1.21	1.55	1.60	0.05	3.2%
Other Compensation[1]	1.58	2.40	2.40	-	-
Awards	1.45	1.89	1.92	0.03	1.6%
Subtotal, FTE Compensation	$158.56	*$166.05*	*$172.73*	*$6.68*	*4.0%*
Benefits	*42.09*	*44.43*	*47.10*	*2.67*	6.0%
Other Benefits[2]	2.23	2.43	2.43	-	-
Subtotal, Benefits	*$44.32*	*$46.86*	*$49.53*	*$2.67*	*5.7%*
COLA[3]	-	1.53	2.09	0.56	36.6%
Total, PC&B	**$202.88**	**$214.44**	**$224.35**	**$9.91**	**4.6%**

Totals may not add due to rounding.

[1] Includes reimbursable details to NSF and terminal leave.

[2] Includes Federal Employee's Compensation Act (FECA) funding, overseas rental housing and education allowance, transit subsidies, and employee relocations.

[3] In FY 2015: includes nine months of the 1.0 percent pay raise; it increases FTE Compensation costs by $1.21 million and Benefits by $331,900. In FY 2016: includes nine months of the projected pay raise of 1.3 percent; it increases FTE Compensation costs by $1.63 million and Benefits by $457,000.

The FY 2016 Request for Personnel Compensation and Benefits (PC&B) of $224.35 million represents an increase of $9.91 million over NSF's FY 2015 Estimate of $214.44 million. The PC&B cost estimate includes an allocation and projected year-end usage of 1,325 regular full-time equivalent (FTE) employee, a total of 42 Pathways intern FTE, a projected 2016 pay raise of 1.3 percent, associated cost of benefits, general workforce performance awards (GWFPA) set at one percent of the salary pool, and Senior Executive Service (SES) bonuses based on five percent of the SES salary pool. The FTE allocation and usage of 1,325 regular and 42 Pathways FTE represents an increase of 15 regular FTE from the FY 2015 Estimate. The increase reflects additional FTE to support two government wide initiatives: five to establish an NSF Digital Service team, and ten to support DATA Act implementation requirements.

The success rate of government digital services is improved when agencies have digital service experts on staff with modern design, software engineering, and product management skills. To ensure the agency can effectively build and deliver important digital services, the FY 2016 Budget includes funding for staffing costs to build a Digital Service team that will focus on transforming the agency's digital services with the greatest impact to citizens and businesses so they are easier to use and more cost-effective to build and maintain.

These digital service experts will bring best practices from outside government in the disciplines of design, software engineering, and product management to bear on the agency's most important services. This will encourage a continuous influx of up-to-date design and technology skills into the agency. The digital service experts will join with the agency's top technical and policy leaders to deliver meaningful and lasting improvements to the services the agency provides to citizens and businesses.

This digital service team will build on the success of the United States Digital Service team inside of OMB, created in 2014. Since standing up, this small OMB team of has worked in collaboration with

Federal agencies to implement cutting edge digital and technology practices on the nation's highest impact programs, including the successful re-launch of HealthCare.gov in its second year, which led to millions of Americans receiving health coverage; the Veterans Benefits Management System; online visa applications, green card replacements and renewals; among others. In addition to their work on these high priority projects, this small team of tech experts has worked to establish best practices (as published in the U.S. Digital Services Playbook at playbook.cio.gov) and to recruit still more highly skilled digital service experts and engineers into government.

The DATA Act expands the Federal Funding Accountability and Transparency Act in an effort to improve the transparency of Federal spending. The Act requires public display on USAspending.gov:

- For each appropriations account, including expired and unexpired appropriations account, the amount of budget authority appropriated; that is obligated; of unobligated balances; and of any other budgetary resources;
- Of information from which accounts and in what amount appropriations are obligated for each program activity and outlays are made for each program activity;
- Of information from which accounts and in what amount appropriations are obligated for each object class and outlays are made for each object class; and
- Of information for each program activity, the amount obligated for each object class and of outlays made for each object class.

In addition, the Act requires establishment of Government-wide financial data standards for any Federal funds made available to or expended by Federal agencies and entities receiving Federal funds. NSF places a high priority both on providing high-quality, transparent Federal spending information to the public and using this expanded data to achieve a more effective and efficient allocation of resources to meet mission needs as well as using this data to improve overall agency performance.

The FY 2016 Request provides funding to accelerate efforts needed to meet the requirements of the DATA Act, including disclosure of all Federal spending and standardization of spending data. To this end, NSF will take steps to integrate procurement and financial assistance award identifications into its financial system, as well as evaluate the feasibility of implementing these new standards into its financial system. Additionally, NSF will take actions to develop new automated mechanisms to report data for publication on USAspending.gov using new standards (this includes data elements, determination of authoritative source, and exchange formats) that are under development and will be issued in FY 2015. NSF will also take steps to readily report obligations and outlays from budgetary account balances in its financial system for program activities and object classes.

Management of Human Capital (+$1.89 million, to a total of $10.0 million)

Management of Human Capital
(Dollars in Millions)

FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Change over FY 2015 Estimate Percent
$10.69	$8.11	$10.00	$1.89	23.3%

This level of funding in FY 2016 will enable NSF to maintain basic operational support activities (including those received from shared service providers) and training and development programs essential for NSF's permanent and rotator staff, while expanding contractual support for human capital initiatives aimed at succession planning and preparation for the NSF headquarters move. The $10.0 million is an increase of $1.89 million over the FY 2015 Estimate and will be used to:

- Maintain funding for NSF's basic HR systems accessed through shared service providers, such as the Federal Personnel Payroll System, the time and attendance system (WebTA), eRecruit capabilities using USAJobs, security investigations for incoming staff, and for implementation of new services for onboarding employees. FY 2016 funding for these activities will be $929,500, an increase of $28,400 from the FY 2015 Estimate.
- Provide the day-to-day operational support for recruiting, hiring, and on-boarding of permanent and rotating staff, as well as processing support for pay and benefits and incentives and other awards. FY 2016 funding for these activities will be $2.50 million, a reduction of $300,000 from the FY 2015 Estimate. These savings reflect efficiencies achieved within the operational services contract due to migration of some activities to shared service providers.
- Continue workplace and work-life support for employees through NSF's health and family-friendly activities, including the Health Unit, the Employee Assistance Program, and the child care subsidy. FY 2016 funding for these activities will be $815,000, an increase of $15,000 from the FY 2015 Estimate to provide for anticipated cost increases.
- Maintain contracts in support of training and development programs, such as the Learning Management System, LearnNSF, and related on-line training capabilities, as well as support for training and networking activities including the NSF mentoring program, executive and supervisory training, and program management training. FY 2016 funding for these activities will be $2.70 million, an increase of $14,000 from the FY 2015 Estimate to reflect continuing costs for the leadership development programs initiated in FY 2015.
- Expand funding for strategic human capital support contracts by $2.13 million to a total of $2.86 million. Primary focus will be implementing a set of high-priority explicit strategies to retain a large fraction of NSF's current permanent staff through the transition to a new headquarters location, and to replace both the rotator population and retirements anticipated between now and then. These strategies will grow out of short "pulse" surveys, focus groups, and other mechanisms for information gathering implemented during FY 2015. Strategies will include a mix of workforce and succession planning, recruitment and hiring approaches, improvements to performance management systems, and retention strategies, including aspects of employee engagement, diversity, and inclusion. Funding will also include accelerated development of human capital Business Intelligence capabilities, including tools accessible to managers across the agency, as well as continued exploration of how shared services can assist the agency in automating processes currently conducted manually. Finally, these funds will be used to conduct NSF activities in support of the President's Management Agenda, ensuring NSF is able to make progress in all areas of the government-wide People and Culture objectives.
- Maintain funding for other program support, including licenses for key on-line reference materials, recruitment, and outreach at $200,000, equal to the FY 2015 Estimate.

Travel (+ zero, to a total of $5.45 million)

Travel
(Dollars in Millions)

FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Percent
$4.83	$5.45	$5.45	-	-

The FY 2016 Request amount of $5.45 million is held flat with the FY 2015 Estimate. This funding level reflects the caps on travel spending established in FY 2012, and this funding supports site reviews, post-award monitoring and oversight, and outreach activities.

Information Technology (-$10,000, to a total of $21.99 million)

NSF funds administrative applications from the AOAM account while mission-related information technology (IT) investments that support the merit review process are funded from program accounts. Resources to support mission-related IT investments are discussed in the Program Related Technology (PRT) section of the Program Accounts narrative beginning on R&RA and EHR-2.

Administrative applications services and support; associated IT operations and infrastructure; and related security and privacy services funded by the AOAM account are discussed below.

AOAM Information Technology
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Change over FY 2015 Estimate Percent
Administrative Applications Services and Support	$6.80	$5.37	$5.11	-$0.26	-4.8%
Associated IT Operations and Infrastructure	9.48	13.84	13.84	-	-
Related Security and Privacy Services	1.76	2.79	3.03	0.24	8.7%
Total, AOAM IT	**$18.04**	**$22.00**	**$21.99**	**-$0.01**	**0.0%**

Totals may not add due to rounding.

Information technology for agency operations ensures high quality, reliable, and secure administrative applications and associated IT infrastructure support and services to meet the needs of the Foundation.

For FY 2016, NSF's information technology priorities for AOAM include:

- Supporting the continued operation and adoption of iTRAK, the Foundation-wide strategic initiative to transition NSF from its aging financial management system to a fully integrated financial management solution;
- Supporting the move of NSF's headquarters; and
- Enhancing NSF's continuous monitoring processes and solutions in alignment with federal cybersecurity priorities.

Administrative Applications Services and Support (-$260,000, to a total of $5.11 million)
Investments in this category support administrative applications, such as NSF's human resources management systems, iTRAK, and the NSF website.

- In FY 2016, $1.35 million will be used for ongoing operations and maintenance of the systems that support the strategic management of NSF human capital, including those to enable the effective recruitment, retention, development, and use of NSF staff and that align with NSF's Strategic Goal 3: Excel as a Scientific Federal Agency, Strategic Objective 1: Build an increasingly diverse, engaged high performing workforce by fostering excellence in recruitment, training, leadership, and human capital management. This represents no change from the FY 2015 Estimate.
- iTRAK became operational the start of FY 2015. In FY 2016, the total request for iTRAK is $5.70 million. Seventy percent of this request will be funded by PRT and 30 percent will be funded by AOAM. In FY 2016, the AOAM portion of the iTRAK request is $1.71 million. This represents an increase of $392,000 over the FY 2015 Estimate. The increase is required for ongoing operations and maintenance of the new system.
- By FY 2016, NSF's legacy financial and accounting system (FAS) will be retired and replaced by iTRAK; therefore no funding is requested for this investment. This represents a decrease of $1.50 million from the FY 2015 Estimate.

- In FY 2016, $2.05 million will support ongoing operations and routine maintenance of collaboration services, such as SharePoint and the NSF website. This represents an increase of $850,000 over the FY 2015 Estimate to support changes required in NSF's IT systems related to procurement spending and management as well as acquisition workforce changes, in alignment with the Digital Accountability and Transparency Act (DATA Act).

Associated IT Operations and Infrastructure (no change to a total of $13.84 million)
Investments in this category provide basic maintenance and operations for ongoing activities that support administrative applications and services. This infrastructure includes NSF's data center, network, hosting, phone, email, and remote access services.

Additionally, this category includes NSF's call center and customer care services. NSF provides customer care support for internal users (NSF staff) 14 hours per day, five days per week.

Related Security and Privacy Services (+$240,000, to a total of $3.03 million)
Investments in this category include automated configuration management tools that manage security patches and provide proactive protection from viruses, spyware, and other threats. This includes the relative portion of NSF's network security, application security, security control testing and tools, automated vulnerability assessment tools, and remediation and intrusion detection services related to administrative applications.

The $240,000 increase will be used to enhance continuous monitoring capabilities, better posture NSF to respond to cybersecurity vulnerabilities, and to secure the cyber-infrastructure needed for NSF's future headquarters.

Space Rental (+$260,000, to a total of $34.17 million)

Space Rental
(Dollars in Millions)

FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Change over FY 2015 Estimate Percent
$31.20	$33.91	$34.17	$0.26	0.8%

Space Rental includes services provided by the General Services Administration (GSA) related to rent and taxes; utilities, and security provided by the Department of Homeland Security.

The FY 2016 Request for Space Rental is $34.17 million, an increase of $260,000, or 0.8 percent, over the FY 2015 Estimate. NSF currently occupies over 665,000 square feet of space, primarily in two adjoining, leased office buildings located in Arlington, Virginia. The current leases for both Stafford I and Stafford II have been replaced by interim occupancy agreements that extend occupancy until the upcoming move of NSF to Alexandria, Virginia. The interim occupancy agreements were negotiated by GSA with the current landlord and reflect current market rates for the Arlington area. The increase of $260,000 in FY 2016 reflects the rates included in the interim occupancy agreement.

Operating Expenses (+$1.22 million, to a total of $15.04 million)

Operating Expenses
(Dollars in Millions)

FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Change over FY 2015 Estimate Percent
$8.51	$13.82	$15.04	$1.22	8.8%

The FY 2016 Request for Operating Expenses is $15.04 million, an increase of $1.22 million, or 8.8 percent, over the FY 2015 Estimate. Operating Expenses include funding for supplies and equipment, contracts, and other costs necessary to enable accomplishment of NSF's research and education mission, as well as to support a wide variety of financial and award management, leadership, and other activities.

The requested amounts and key activities funded by NSF's FY 2016 Request are described below:

- Funding of $5.53 million, equal to the FY 2015 Estimate, for training, equipment, communications devices, printing, and supplies for NSF's directorates and offices. This level is based on the amount of funding required for the projected regular FTE usage of 1,325.
- In FY 2016, $4.04 million, an increase of $873,000 over the FY 2015 Estimate, is for award management and oversight support services (AMOSS) in the areas of post-award monitoring, contract closeout activities, large facility oversight, and outreach activities/materials planned for NSF grantees. The total FY 2016 funding amount for this activity is lower than historical levels. The increase over FY 2015 is due to forward funding in FY 2014 of approximately nine months of the FY 2015 costs.
- FY 2016 funding of $1.35 million (-$512,000 below the FY 2015 Estimate) is for financial management support, including financial statement reporting, NSF property reporting, audit findings resolution assistance, and reporting associated with the financial system. The decrease in funding reflects a new level of support with NSF's new financial system, ITRAK, deployed in October 2014.
- Funding of $655,000 to support NSF's internal control quality assurance activities including documenting, testing, and assessing internal control effectiveness, including effectiveness and efficiency of operations, reliability of financial reporting, and compliance with applicable laws and regulations. This increase of $328,000 over the FY 2015 Estimate is due to forward funding in FY 2014 of approximately six months of the FY 2015 cost.
- Support for the Enterprise Information System (EIS) and the Budget Internet Information System (BIIS) to provide accurate, consistent information on funding rate, award size, and other statistics to NSF staff and the public, remains equal to the FY 2015 Estimate level of $375,000. This level of support ensures that the system and related data analysis will continue to respond to evolving information needs and is integrated with iTRAK.
- In FY 2016, $360,000, an increase of $338,000, for on-going licensing, subscription, and infrastructure support for the Automated Acquisition Management System (AAMS) – NSF's E-procurement system. The increase over FY 2015 is due to forward funding in FY 2014.
- Funding of $280,000 in FY 2016, an increase of $100,000 over the FY 2015 Estimate, provides support for the required annual update of our improper payments risk assessment per the Improper Payments Elimination and Reduction Act (IPERA), and NSF's verification and validation of grant expenditure accrual. The results are used to support NSF's post-award monitoring program. The increase over FY 2015 is due to forward funding in FY 2014 of approximately six months of the FY 2015 cost.

- FY 2016 funding of $288,000, an increase of $38,000 above the FY 2015 Estimate, supports activities including administrative grants processing duties, processing funding actions, reviewing payment requests.
- $250,000 in FY 2016, a decrease of $50,000 from the FY 2015 Estimate, will provide support for increased cost analysis responsibilities due to the implementation of Standardized Cost Analysis Guidance, which became effective June 2014.
- FY 2016 funding of $250,000 for contract support, an increase of $198,000 above the FY 2015 Estimate, provides additional support for the Office of Polar Programs' contract requirements and for the purchase card program review and transaction support. The increase over FY 2015 is due to forward funding in FY 2014 of approximately six months of the FY 2015 cost.
- FY 2016 funding of $225,000 will support the Cost Analysis and Audit Resolution (CAAR) branch in setting Indirect Cost Rates (ICRs), a federally mandated function that directly supports awardee business operations. CAAR will pilot increasing availability of contractor subject matter expertise to supplement/enhance staff skills needed for an anticipated increase in complex rate negotiations to address issues of concern from the OIG, e.g., unfunded liabilities under AURA/LSST. No funding was requested for this activity in FY 2015 as the FY 2014 funding covered two years of support. This funding request is for FY 2016 only, and this level of funding provides assurance of uninterrupted transition to FY 2017.
- FY 2016 funding of $250,000 is for reasonable accommodations that NSF is responsible for providing to persons with disabilities, including NSF employees, applicants, and those conducting business at NSF. Funding is held flat with the FY 2015 Estimate. Activities supported assist with maintaining NSF's model Equal Employment Opportunity status, since not providing accommodations could be viewed as discrimination according to Sections 501 and 505 of the Rehabilitation Act of 1973.
- FY 2016 funding of $220,000 is for the congressionally-mandated Committee on Equal Opportunities in Science and Engineering (CEOSE) activity. This request covers contractor services and meeting support for CEOSE, which acts as an NSF advisory committee that provides advice on policies and programs to broaden participation of women, minorities, and persons with disabilities. This funding level is the same as the FY 2015 Estimate.

Building and Administrative Services (+$2.61 million, to a total of $13.07 million)

Building and Administrative Services

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Change over FY 2015 Estimate Percent
Information Dissemination	$4.59	$1.62	$2.93	$1.31	80.9%
Workplace Management	6.51	5.11	5.03	-0.08	-1.6%
Panel Support, Meeting Management, and Proposal Services	4.31	3.73	5.11	1.38	37.0%
Total, Building & Admin Services	**$15.41**	**$10.46**	**$13.07**	**$2.61**	**25.0%**

Totals may not add due to rounding.

The FY 2016 Request level of $13.07 million represents an increase of $2.61 million, or 25 percent, over the FY 2015 Estimate. The funding associated with Building and Administrative Services will support three sets of activities: information dissemination; workplace management; and panel support, meeting management, and proposal services.

Information Dissemination (+$1.31 million, to a total of $2.93 million)
Investments in this category fund activities that support NSF's website and intranet operations and maintenance, as well as user interface design. These funds support extensive web-based and electronic information distribution tools that provide information to both NSF staff and the public regarding the NSF mission and related content. This category also includes funding for website and business application development and support, graphic design and commercial printing, and regulatory reporting processing and production.

An increase of $1.31 million above the FY 2015 Estimate will enhance efforts to design, develop, and modernize NSF's websites. This includes plans to streamline assets used in the development of NSF websites and NSF web applications through retirement of dated technology and migration to modern platforms. This modernization provides a number of benefits to the current environment, including reduced maintenance support, integration with other modern architectures, enhanced content management functionality, and improved reliability and performance.

Workplace Management (-$80,000, to a total of $5.03 million)
Workplace Management provides funding for core business activities and infrastructure support related to security and emergency management, such as security badge issuance, management of NSF Continuity of Operations Plan activities, and physical security and access control. Funding in this category also supports space management and facility operations, including development of space plans and assignments, space reconfigurations, and facility service and maintenance. Additionally, this funding supports activities related to property and records management – the oversight and planning of mailroom shipping and receiving operations; property receipt, inventory, and tracking; and the establishment and execution of records management policies and procedures.

The $80,000 decrease in FY 2016 for Workplace Management will be realized through strategic sourcing of facility operations contracts.

Panel Support, Meeting Management, and Proposal Services (+$1.38 million, to a total of $5.11 million)
Investments in this category are used to provide critical support at all stages of NSF's merit review process (including pre-, during-, and post-meeting customer support). This funding also includes services provided in the scheduling and coordination of onsite and virtual panels; activities to oversee, operate, and maintain mission critical virtual communications equipment and resources; management of central conference space and audiovisual and communications equipment; travel management services for NSF staff and panelists; technical support and management oversight of proposal processing; and library and research assistance.

In FY 2016, an increase of $1.38 million over the FY 2015 Estimate will fund various electronic library subscriptions and maintenance services supporting library operations, and will enhance support for both onsite and virtual panelists and peer reviewers. These activities benefit the NSF mission by promoting the merit review process and providing access to field specific research material used by the program staff.

NSF Headquarters Relocation (+$13.96 million, to a total of $30.77 million)

NSF Headquarters Relocation
(Dollars in Millions)

FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Percent
$14.39	$16.81	$30.77	$13.96	83.0%

Totals may not add due to rounding.

The FY 2016 Request for NSF Headquarters Relocation is $30.77 million, an increase of $13.96 million over the FY 2015 Estimate.

NSF headquarters has been located in Arlington, VA since 1993. Initially, the agency occupied the Stafford I building and subsequently expanded into an adjacent building (Stafford II) as the mission, operations, and staff grew over the 20-year lease period. Leases for both facilities expired in CY 2013. Extended leases are currently in place through CY 2017.

NSF has worked collaboratively with the GSA since 2008 to procure a new long-term lease. After an active response from the Northern Virginia real estate market, on June 7, 2013, GSA awarded a lease for a new to-be-built development in Alexandria, VA. The new lease agreement included a number of cost-savings credits to the government and a substantial funding incentive by the City of Alexandria to offset either NSF's costs for design and construction of the agency's space or for new rent. The lease also included other savings to NSF through a reduced rental rate and real estate tax freeze over the life of the lease.

Funding in FY 2016 is required to provide continuity in managing the agency's responsibilities in this effort including, oversight of the NSF-related design, engineering and construction, conducting and coordinating procurements (specific to the infrastructure, migration, and furnishing of the new space, and integration management of IT and other mission-related technology requirements) with GSA and the design and construction teams, planning NSF relocation activities, as well as specifying and coordinating Department of Homeland Security features and systems into the project. These items commenced in FY 2013/2014 and continue through completion in FY 2017 in coordination with the sequence of project design, construction, and occupancy schedules and conditions.

The FY 2016 Request will support the following NSF HQ Relocation activities:

- Program Management: $2.67 million for ongoing technical expertise necessary to ensure that the associated work for the new NSF headquarters is being designed, constructed, coordinated, and executed to support NSF's mission with minimal disruption and provide the best value to the taxpayer, including:
  - Project coordination, architecture and design management, engineering and construction management, and Leadership in Energy and Environmental Design (LEED) support;
  - Relocation planning and execution of NSF personnel, leading to final occupancy and turnover;
  - Interior design coordination and management;
  - Furniture procurement support; and
  - Information technology design, construction management, and coordination between existing NSF systems and the new HQ in all areas of data, voice, video, audio/visual, satellite, electronic security, new technology integration, operations, and wired and wireless network services to maintain NSF's mission continuity during the move.

- Technology Costs: $14.68 million is required in FY 2016 to procure the multi-year design, equipment and services, installation, integration, and testing of IT and mission-related technology for the new HQ including:
  - Specialized IT infrastructure connectivity, migration of existing equipment, and new, updated services and equipment, including installation, integration, testing, and training;
  - Critical IT systems, audio/visual, and video-teleconferencing components, including virtual technology tools and systems; and
  - Integrated electronic security/access control and intrusion detection and camera systems and physical security elements with IT network and other management components.

- Furniture, Furnishings and Equipment Costs: $13.42 million will be used to complete the multi-year procurement of systems furniture and compatible/interchangeable closed office furniture components including new task seating for staff, and new furniture requirements in the cafeteria, conference, and other areas where reuse is not possible (NSF plans to reuse 30 percent of the existing furniture and transfer it to the new location). The procurement will be competitively based, will comply with LEED Commercial Interior goals, and will incorporate design, fabrication, project management, and installation by the awarded vendor.

AOAM by Object Class

AOAM by Object Class

(Dollars in Thousands)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Change over FY 2015 Estimate Percent
Personnel Compensation	$157,177	$167,250	$174,360	$7,110	4.3%
Personnel Benefits	44,125	47,194	49,987	2,793	5.9%
Travel and Transportation of Persons	4,830	5,450	5,450	-	-
Transportation of Things	478	382	380	-2	-0.5%
Rental Payments to GSA	30,100	33,910	34,168	258	0.8%
Rent to Others	14	-	-	-	N/A
Communications, Utilities and Misc. Charges	3,478	2,693	3,688	995	36.9%
Printing and Reproduction	138	105	113	8	7.6%
Advisory and Assistance Services	42,183	41,479	42,093	614	1.5%
Other Services	9,232	8,500	9,200	700	8.2%
Purchases of Goods & Srvcs from Gov't. Accts	8,620	8,500	9,000	500	5.9%
Operations and Maintenance of Equipment	78	37	40	3	8.1%
Supplies and Materials	2,901	2,500	2,941	441	17.6%
Equipment	2,596	7,000	23,420	16,420	234.6%
Land and Structures	-	-	-	-	N/A
Total, AOAM	**$305,952**	**$325,000**	**$354,840**	**$29,840**	**9.2%**

Totals may not add due to rounding.

FY 2016 Request Object Class Code estimates mirror the FY 2016 request for AOAM and similarly reflect an increase of $29.84 million over the FY 2015 Estimate, including $13.96 million for costs associated with NSF's relocation to Alexandria.

Personnel Compensation and Benefits: Personnel compensation funds payroll, awards/bonuses, reimbursable details to NSF, overtime, and terminal leave. Personnel Benefits include the Government's contribution towards retirement systems, health and life insurance, thrift saving plans, special overseas allowances, unemployment insurance, transit subsidies, and employee relocations.

Personnel Compensation increases by $7.11 million over the FY 2015 Estimate to support an increase in usage of 15 FTE and the projected 1.3 percent pay raise in FY 2016.

Personnel Benefits increase by $2.79 million over the FY 2015 Estimate as a result of the increase in FTE utilization and the 1.3 percent pay raise.

Travel and Transportation of Persons: These resources fund travel required for planning, outreach, and the increased oversight of existing awards recommended by the agency's Inspector General.

Transportation of Things: This category consists of household moves associated with bringing new staff to NSF.

Rental Payments to GSA: This category includes the rent charged by GSA for NSF's facility in Arlington, Virginia, and additional floors currently leased in an adjacent building.

Communications, Utilities, and Miscellaneous Charges: This category includes all costs for telephone and other communication lines and services, both local and long distance, and postage.

Printing and Reproduction: This category includes contract costs of composition and printing of NSF's publications, announcements, and forms, as well as printing of stationery and specialty items.

Advisory and Assistance Services: This category includes development, learning, and career enhancement opportunities offered through the NSF Academy; contracts for human capital operational activities, work life initiatives, outreach, and related services; assistance in award oversight and monitoring; support for OMB Circular A-123 reviews; and program management costs in support of NSF's new headquarters.

Other Services: This category includes warehousing and supply services, mail handling, proposal processing, equipment repair and maintenance, building-related costs, furniture repair, contract support for conference room services, security investigations, and miscellaneous administrative contracts.

Purchases of Goods and Services from Government Accounts: This category includes reimbursable services purchased from other government agencies. Examples include GSA for security guard services, some electrical upgrades, and modest renovation services, and Department of the Interior for payroll services.

Operation and Maintenance of Equipment: This category includes management and operation of the central computer facility 24x7 year-round; operation of the customer service center and FastLane help desk; maintenance of database server hardware and related peripherals; software licensing fees; data communications infrastructure and network systems support; electronic mail support; and remote access (e.g., internet and World Wide Web).

Supplies and Materials: This category includes office supplies, library supplies, paper and supplies for the NSF central computer facility, and miscellaneous supplies.

Equipment: This category includes new and replacement computing equipment, desktop computers, data communications equipment, video-teleconferencing equipment, office furniture, file cabinets, and support equipment such as audio-visual equipment. In FY 2016, this category includes equipment costs related to NSF's relocation to Alexandria.

Appropriations Language

For agency operations and award management necessary in carrying out the National Science Foundation Act of 1950 (42 U.S.C. 1861 et seq.); services authorized by section 3109 of title 5, United States Code; hire of passenger motor vehicles; uniforms or allowances therefor, as authorized by sections 5901 and 5902 of title 5, United States Code; rental of conference rooms in the District of Columbia; and reimbursement of the Department of Homeland Security for security guard services; ~~$325,000,000:~~*$354,840,000: Provided*, That not to exceed $8,280 is for official reception and representation expenses: *Provided further*, That contracts may be entered into under this heading in fiscal year ~~2015~~*2016* for maintenance and operation of facilities and for other services to be provided during the next fiscal year; *Provided further*, That of the amount provided for costs associated with the acquisition, occupancy, and related costs of new headquarters space, not more than ~~$27,370,000~~*$28,400,000* shall remain available until expended~~.~~: *Provided further, That $2,852,000 will be used to support the agency's activities related to implementation of the Digital Accountability and Transparency Act (DATA Act; Public Law 113–101; 31 U.S.C. 6101 note) to include changes in business processes, workforce, or information technology to support high quality, transparent Federal spending information, of which $852,000 shall be available to support the agency's implementation of a uniform procurement instrument identifier as described in 48 C.F.R. subpart 4.16.*

Agency Operations and Award Management
FY 2016 Summary Statement
(Dollars in Millions)

	Enacted/ Request	Transfers	Expired	Obligations Actual/ Estimates
FY 2014 Appropriation	$298.00	$8.26	-$0.31	$305.95
FY 2015 Estimate	325.00			325.00
FY 2016 Request	354.84			354.84
$ Change from FY 2015 Estimate				$29.84
% Change from FY 2015 Estimate				9.2%

Totals may not add due to rounding.

NATIONAL SCIENCE BOARD (NSB) $4,370,000
+$0 / 0.0%

The FY 2016 Budget Request for the National Science Board is $4.37 million, which is equal to the FY 2015 Estimate of $4.37 million. The FY 2016 Budget Request will enable the Board to fulfill its policymaking responsibilities for NSF and allow the Board to continue its responsibilities as outlined in the agency's Organic Act, including activities related to the review of major research facilities projects.

National Science Board Funding
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request[1]	FY 2016 Request Change Over FY 2015 Estimate Amount	Percent
Total, NSB	**$4.25**	**$4.37**	**$4.37**	-	-
Full-Time Equivalents (FTEs)	19	19	19	-	-

Totals may not add due to rounding.

[1] FY 2016 includes a provisional pay raise of 1.3 percent, as well as anticipated within grade and promotion increases.

Appropriations Language

For necessary expenses (including payment of salaries, authorized travel, hire of passenger motor vehicles, the rental of conference rooms in the District of Columbia, and the employment of experts and consultants under section 3109 of title 5, United States Code) involved in carrying out section 4 of the National Science Foundation Act of 1950 (42 U.S.C 1863) and Public Law 86-209 (42 U.S.C. 1880 et seq.), $4,370,000: *Provided*, That not to exceed $2,500 shall be available for official reception and representation expenses.

National Science Board
FY 2016 Summary Statement
(Dollars in Millions)

	Enacted/ Request	Expired	Obligations Actual/ Estimates
FY 2014 Appropriation	$4.30	-$0.05	$4.25
FY 2015 Estimate	4.37		4.37
FY 2016 Request	4.37		4.37
$ Change from FY 2015 Estimate			-
% Change from FY 2015 Estimate			-

Totals may not add due to rounding.

National Science Board in Context

The National Science Board, established by the NSF Act of 1950, has dual responsibilities to: a) provide national science policy advice to the President and Congress; and b) establish policies for NSF. The Board consists of 24 presidentially-appointed members plus the Director of NSF as an *ex officio* member. Representing the broad U.S. science and engineering (S&E) community, the Board serves collectively as an advisory body on S&E issues critical to the Nation. Board members serve 6-year terms on staggered

appointments and are drawn from industry, academe, non-profit organizations and professional scientific societies representing the breadth of S&E disciplines supported by NSF. They are selected for their eminence in research, education, or public service.

The Board currently meets for five formally scheduled meetings per year, with additional meetings as needed, to review and approve major NSF awards and new programs; oversee and provide policy direction to NSF; and address significant science and engineering related national policy issues. The Board initiates and conducts studies and reports on a range of policy topics and reviews NSF's priorities both to ensure progress and consistency along the strategic direction set for NSF and to ensure balance among new investments and core programs.

Policy Responsibilities

Issues of importance to the science, engineering, and education communities in general and to NSF in particular are often examined by the Board. Topics for exploration are determined through requests from Congress or the President or as identified by the Board in consultation with the science community and NSF management. Recent reports have examined topics such as administrative burdens on researchers, merit review, mid-scale instrumentation, data policies, rising costs, public research universities, science and engineering education, and the U.S. innovation system.

In addition to those special studies, the Board has several standing committees to assist with its responsibilities. The Committee on Audit and Oversight (A&O) provides general supervision for the NSF Inspector General; oversight of major agency administrative processes and principal administrative systems; and review of the agency's internal controls.

The Committee on Strategy and Budget (CSB) focuses on strategic planning and new investments for NSF; analyzes the Foundation's budget to ensure progress and consistency against strategic direction for the Foundation; and identifies strategic, typically long-term, issues that are critical to NSF's future. Within CSB, the Subcommittee on Facilities (SCF) provides guidance and review of NSF-funded research equipment and facilities portfolio, including both Major Research Equipment and Facilities Construction (MREFC) account-funded and Research and Related Activities (R&RA) account-funded facilities.

The Committee on Education and Human Resources (CEH) focuses on policy direction and advice on major policy issues related to the NSF education, informal science, and training portfolio. It also provides advice on major national policy issues in science, technology, engineering, and mathematics (STEM) education, human resource needs and employment, and human resource development for consideration by the Board.

The Committee on Science and Engineering Indicators (SEI) oversees the development, production of, and recommends approval to the Board to release Board's biennial report, *Science and Engineering Indicators*, and other related products; and keeps the Board informed on trends and other data with significant policy implications identified during the production of *Indicators*. The Board's publication of *Science and Engineering Indicators* is a statutory responsibility. Over the past several years, the Board has heightened its efforts to increase the accessibility of *Indicators*, implementing enhancements such as the online *Digest of Key Science and Engineering Indicators* that allow audiences outside the usual community of users to become familiar with the data resources, and to facilitate the use of *Indicators* data in policy decisions and analyses. The 2014 edition of *Indicators* was transmitted to Congress and the President on February 6, 2014. The Board has also developed additional policy statements based on the *Indicators* data to assist policymakers in their deliberations on science and technology issues as well as an

update to the STEM Education Data and Trends web tool which emphasizes and highlights various *Indicators* data points of particular interest to educators and education stakeholders.

The Board is responsible for direct review and approval of the Foundation's largest awards, and is responsible for the review and approval of MREFC projects at all stages of development, including budget planning, review of proposals and management effectiveness, and approval of awards. The Committee on Programs and Plans (CPP) provides guidance and advice on major policy issues related to the NSF R&RA portfolio, reviews proposals representing a significant expenditure of agency resources, and makes recommendations, as appropriate, to the full Board for its consideration and action. CPP also provides oversight, guidance, and advice on major policy and operational issues related to the NSF polar research portfolio.

The Board's Executive Committee (EC) consists of the director for NSF, who chairs the Committee, and four elected members from the Board. The Board may delegate to the Executive Committee or to the director for NSF or both, powers and functions granted to the Board by the NSF Act.

Ongoing activities of the Board include review and approval of the following:
- Large awards, MREFC projects, or proposal funding requests and other proposals as needed;
- NSF's Management Response to the Office of Inspector General (OIG) Semi-annual Reports to Congress;
- The NSF, OIG, and the NSB budget submissions to the Office of Management and Budget (OMB);
- The priority order of projects in the MREFC Account;
- Inclusion of new project(s) requiring funding under the MREFC Account; and
- The NSF Strategic Plan.

The Board also receives reviews of the following from NSF:
- Financial management reports for NSF;
- The operation of NSF's merit review system;
- NSF research infrastructure portfolio; and
- NSF human capital reports.

Office of the National Science Board

Personnel Compensation and Benefits and General Operating Expenses

(Dollars in Thousands)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request[1]	FY 2016 Request Change Over FY 2015 Estimate Amount	Percent
Personnel Compensation Benefits (PC&B)	$3,038	$3,126	$3,126	-	-
Staff Development and Training	34	36	36	-	-
Advisory and Assistance Services	870	721	730	9	1.2%
Travel and Transportation of Persons	229	344	335	-9	-2.6%
Communications, Supplies, and Equipment	77	140	140	-	-
Representation Costs	2	3	3	-	-
Total, NSB	**$4,250**	**$4,370**	**$4,370**	**-**	**-**
Full-Time Equivalent	19	19	19	-	-

Totals may not add due to rounding.

[1] FY 2016 PC&B includes a pay raise of 1.3 percent, as well as anticipated within grade and promotion increases.

Personnel Compensation and Benefits

The Board's FY 2016 Budget Request supports a core of full-time policy, administrative, legal, and operations staff. In addition to providing institutional memory for the Board, the Board Office staff provides both the resources and expertise for coordinating and implementing science and education policy analyses and development, broad communication and outreach programs, advice to the Board on legal aspects of its policies and activities, and operational and administrative support that are essential for the Board to fulfill its mission.

Other Operating Expenses

NSB's Advisory and Assistance Services includes the resources needed to produce policy reports to include the Board's *Science and Engineering Indicators*, which is a statutory responsibility. Over the past several years, the Board has heightened its efforts to increase the accessibility of *Indicators*, including the development of companion reports. The 2016 edition of *Indicators* is scheduled for release to Congress in February 2016.

Most of the Board's reports require expert analysis from organizations such as the Science and Technology Policy Institute, a Federally Funded Research and Development Center supported by NSF. Another major expense in the Advisory and Assistance Services line is the development and maintenance of a content management system to search, identify, and retrieve relevant documents for reference and research purposes. This content management system houses substantive Board materials, such as discussions, decisions, and meeting minutes, and will guide our efforts in meeting the requirements of transparency, participation and collaboration as directed by the Memorandum on Transparency and Open Government issued by OMB in 2009. Other costs within the Advisory and Assistance Services line are associated with the Open Government initiative including the webcasting and archiving of all open Board meetings, as well as transcription services, and report printing and dissemination.

NSB's Travel and Transportation of Persons account primarily covers Board member travel costs to NSF headquarters for five meetings, as well as travel for invited speakers and participants in Board activities. The Communications, Supplies, and Equipment line funds the range of electronic purchases, upgrades and installations, such as copiers and computers.

The FY 2016 Request level will facilitate the continued thoughtful enhancement of the Board's media and online outreach efforts that have been successfully used to inform the general public and STEM communities about the Board's activities and the availability of its published reports and other informative materials. Such efforts will continue to expand the community served by the Board on issues and activities relevant to S&E research and education. Further, these enhanced outreach capabilities will incorporate the advice and guidance of media and online communications experts and consultants who will recommend and advise the Board on the best practices for reaching targeted audiences via the press and/or media interactions, as well as online.

OFFICE OF INSPECTOR GENERAL (OIG) $15,160,000
+$730,000 / 5.1%

The Appropriations Act that funds the National Science Foundation provides for a separate appropriation for NSF's Office of Inspector General (OIG). Accordingly, this FY 2016 Budget Request identifies the resources needed to support OIG, including amounts for personnel compensation and benefits (PC&B), contract services, training, travel, supplies, materials, and equipment.

The FY 2016 Budget Request for OIG is $15.16 million, an increase of $730,000 from the FY 2015 Estimate of $14.43 million.

Office of Inspector General Funding
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	FY 2016 Request Change Over FY 2015 Estimate Amount	FY 2016 Request Change Over FY 2015 Estimate Percent
Total, OIG	**$13.84**	**$14.43**	**$15.16**	**$0.73**	**5.1%**
Full-Time Equivalents (FTEs)	67	73	75	2	2.7%

Appropriations Language

For necessary expenses of the Office of Inspector General as authorized by the Inspector General Act of 1978, ~~$14,430,000,~~*$15,160,*000, of which $400,000 shall remain available until September 30, ~~2016.~~*2017*.

Office of Inspector General
FY 2016 Summary Statement
(Dollars in Millions)

	Enacted/ Request	Unobligated Balance Available Start of Year	Unobligated Balance Available End of Year	Adjustments to Prior Year Accounts	Transferred	Obligations Actual/ Estimates
FY 2014 Appropriation	$14.20		-$0.40	-$0.04	$0.08	$13.84
FY 2015 Estimate	14.43	0.40			-	14.83
FY 2016 Request	15.16				-	15.16
$ Change from FY 2015 Estimate						$0.33
% Change from FY 2015 Estimate						2.2%

Totals may not add due to rounding.

Explanation of Carryover

Within the **Office of Inspector General (OIG)** account, $400,000 in two-year funds was carried over into FY 2015. Most of these funds are expected to be used to procure audit and forensic contracts during the second quarter of FY 2015. The selection of awards and institutions to be audited will require careful preparation and is subject to changing circumstances and new information that may require additional time to process.

OIG Responsibilities

In February 1989, the National Science Board established OIG pursuant to the Inspector General Act Amendments of 1988. The statute confers on OIG the responsibility and authority to:

- Conduct and supervise audits of NSF programs and operations, including organizations that receive NSF funding;
- Conduct investigations concerning NSF programs and operations, including organizations that receive NSF funding;
- Evaluate allegations of research misconduct, such as fabrication, falsification, or plagiarism, involving individuals who participate in NSF-funded activities;
- Provide leadership, coordination, and policy recommendations for:
  - Promoting economy, efficiency, and effectiveness in the administration of NSF programs and operations, and
  - Preventing and detecting fraud and abuse in NSF programs and operations;
- Issue semiannual reports to the National Science Board and Congress to keep them informed about problems, recommended corrective actions, and progress being made in improving the management and conduct of NSF programs.

OIG performs audits of grants, contracts, and cooperative agreements funded by NSF's programs. The office also conducts audits and reviews of both internal agency programs and external organizations that receive NSF funding to ensure that financial, administrative, and programmatic activities are conducted economically, effectively, and in compliance with agency and federal requirements. When appropriate, the office performs multi-disciplinary reviews – involving auditors, attorneys, management analysts, investigators, scientists, and others as needed – of financial, management, and program operations to identify broader problems and highlight best practices. OIG also oversees the audit of NSF's annual financial statements, which are required for all NSF accounts and activities by the Government Management Reform Act of 1994, and audits financial, budgetary, and data processing systems used by NSF to prepare the financial statements.

OIG investigates possible wrongdoing by organizations and individuals who seek or receive NSF funds, such as those who submit proposals to, receive awards from, conduct business with, or work for NSF. The office also investigates allegations of research misconduct by NSF recipients. OIG assesses the validity and seriousness of all the allegations it receives to determine whether or not to pursue legal or administrative action. When appropriate, the office refers the results of these investigations to the Department of Justice or other authorities for criminal prosecution, civil litigation, or resolution via settlement agreements and institutional compliance plans. OIG refers other cases to NSF for administrative resolution and when needed will recommend modifications to agency policies and procedures to assure the integrity of NSF's business systems. The office works closely with institutions on their internal research misconduct investigations and regularly engages in activities aimed at preventing and detecting fraud, waste, and abuse and at raising the awareness of funded researchers, institutional administrators, and agency employees about OIG's role and NSF's rules and expectations.

Because diverse skills, training, and experience are necessary to oversee NSF's many programs, the OIG staff includes scientists, attorneys, certified public accountants, investigators (including special agents), analysts, evaluators, and information technology specialists. The subjects of investigations, audits, and other reviews are also varied and may include: an individual grant recipient or institution; a broad program or functional area of NSF; or a project involving multiple disciplines or entities. In addition, OIG utilizes contractors to perform work when it is cost effective, or when it lacks the necessary expertise in-house, as in the case of the annual review of the agency's financial systems controls and their compliance with the Federal Information Security Management Act of 2014. OIG will maintain its

oversight of the few American Recovery and Reinvestment Act (ARRA) awards that remain active in FY 2016, as well as the many that have expired, as the last of the ARRA awards that received a waiver near completion.

Office of Inspector General

Personnel Compensation and Benefits and General Operating Expenses

(Dollars in Thousands)

	FY2014 Actual	FY 2015 Estimate	FY 2016 Request	FY 2016 Request Change Over FY 2015 Estimate Amount	Percent
Personnel Compensation and Benefits[1]	$10,296	$11,258	$11,916	$658	5.8%
Travel & Transportation of Persons	150	250	270	20	8.0%
Advisory & Assistance Services[2]	3,204	2,612	2,664	52	2.0%
Communications, Supplies, Equipment & Other Services	190	310	310	-	-
Training	*75*	*160*	*150*	*-10*	*-6.3%*
Other	*115*	*150*	*160*	*10*	*6.7%*
Total, OIG	**$13,840**	**$14,430**	**$15,160**	**$730**	**5.1%**
Full-Time Equivalents	67	73	75	2	2.7%

Totals may not add due to rounding.

[1] Includes projected 2016 pay raise of 1.3 percent, as well as anticipated within grade and promotion increases.

[2] Includes the costs of the annual financial statements audit and the outsourcing of contracting services.

An FY 2016 budget of $15.16 million will enable OIG to fill and maintain many of the 13 positions that became vacant since FY 2012 and continue effective oversight of NSF's programs and riskiest awards. Recent budget cuts have impacted the number of audits and investigations performed, as the office's workforce declined 17 percent, from 78 FTE at the start of FY 2013 to 65 in July 2014. OIG is in the midst of hiring as many as nine additional staff in order to return production closer to previous levels. In addition, as the current workforce ages, new hires are critical to revitalizing the organization and will be carefully evaluated not just for technical skills but for succession planning purposes. OIG estimates 29 percent of staff (mostly managers) will be eligible to retire in FY 2016.

During FY 2014, OIG has observed an increase in its average cost of an FTE, as raises and awards have resumed, and higher paid professionals such as lawyers, investigators, and CPAs replace lower paid departing administrative staff. In FY 2016, OIG expects to support 75 FTEs. Our office intends to be judicious in adding new staff in order to preserve future budget flexibility, and will forego returning OIG staffing levels to what they were before FY 2013.

OIG has streamlined its administrative unit, electing to allocate as many FTEs as possible for audits and investigations. Priorities in the near term are to increase the number of audits and investigations conducted. To achieve this goal, OIG will ensure that the necessary number of audit contracts can be procured to rebuild the civil/criminal investigative unit, which has lost a number of investigators to mandatory retirement. Investments in equipment, technology upgrades (e.g., expansion of our data analytics capability for audits and investigations), and the addition of an IT specialist to support these initiatives will continue to be pursued as funds allow. Funding for preventive activities, such as educating researchers at regional conferences about rules and requirements associated with federal grants, as well as other outreach efforts to stakeholders, will continue at a reduced level.

Office of Audits (OA). Over the past two years, OA has been implementing a plan to improve both the efficiency and effectiveness of its external audits in concert with NSF's growing number of grants, contracts, and complex cooperative agreements. OA is employing enhanced technical capabilities and data analytics to improve oversight of NSF funds by 1) better targeting our audits toward the riskiest awardees and 2) more efficiently screening and analyzing large volumes of data. Using analytics, we have increased the number of transactions we are capable of reviewing from dozens to thousands and improved our ability to identify problematic or questionable costs.

Funding will enable OA to hire one performance auditor, and invest approximately $300,000 more toward procuring additional contracted audits. The performance audit unit has been operating without its full complement of staff for several years due to attrition. We estimate that the addition of an FTE will enable OIG to perform one to two additional audits of critical agency programs during FY 2016, including the U. S. Antarctic Program (USAP), which has come under increased scrutiny with the transition of the support contract and the issuance of the 2012 blue ribbon panel report on the programs' logistical challenges. The performance audit unit provides oversight of NSF's management of its programs, monitors the agency's administration of its $7.0 billion budget, and responds to important federal audit priorities. These include assessments of the efficiency and effectiveness of 1) NSF's oversight of grant and contract awardees and 2) the agency's use of financial and personnel resources.

Since FY 2012, OA has lost eight FTEs, representing 24 percent of its workforce, including those with significant experience in grant audits and data analytics that are difficult to replace. The loss of resources has reduced completed audit work from 37 reports in FY 2011 to only 18 in FY 2014, a 51 percent reduction. OA is currently in the process of replacing six of the eight staff it has lost. But despite past staffing challenges, OA's transition to its new business model has already produced promising results. Audits employing this new approach produce a more robust and accurate analysis of federal award expenditures, while reducing the actual cost of planning and conducting the audit. In addition, automated techniques provide a level of transparency of recipient spending that was previously unattainable using traditional audit techniques. Utilizing set rules to perform knowledge discovery on the use of federal funds, data analytics provides insight into determining whether 1) costs were incurred during or after the award period; 2) grant expenditures charged to an award were in the approved budget; and 3) spending increases significantly at the very end of an award period (a fraud-related indicator).

While at present OA continues to utilize both contractors and OIG staff in a variety of roles to conduct audits of awardee institutions, OA is moving more toward a hybrid approach to external audits. The new business model requires in-house staff to conduct the analytics, drawing on their experience in auditing NSF grants to identify the riskiest transactions in the data. OA then provides the questionable data sets to our contractors to go on site at the institutions and perform the transaction testing. Using this combination of in-house staff and contract support maximizes efficiency and avoids the problem of finding and hiring grant auditors with experience in data analytics.

OA is also building grant and cooperative agreement audit capability among its staff to address the riskiest awards. Under this approach, OA combines data analytics examiners with experienced OIG audit staff to test and surface activity that would be of the greatest concern to NSF. The three approaches described provide us with the maximum amount of flexibility and also help to address quality and timeliness issues that we have experienced while using some contractor staff. As one of the first OIGs to adopt these new methods, the office is engaged in teaching others within the Inspector General community how to use analytics to improve the effectiveness of their audits.

Additional funds will also be used to increase the number of contracted audits. The funds will enable OIG to procure and oversee an estimated three or four additional audits, restoring OIG to the level of contracted audits performed over the past three years. Along with analytics, the use of contractors is vital

to the oversight of NSF awards, as it allows for the auditing of larger contracts, cooperative agreements, and grants, such as the multi-year support contract for the U.S. Antarctic Program (USAP). NSF obligates over $330 million per year in Antarctic research awards and associated support contractors. OIG has recently undertaken a comprehensive review and risk assessment of this key NSF program and has committed to expanding its oversight. The review identified a dozen medium- and high-risk areas, such as health and safety, information technology, and deferred maintenance that warrant audit attention. Audits of NSF's IT infrastructure are also part of the office's audit plan, as the agency moves its applications and resources into cloud computing, converts its financial system, and migrates its internet service into the Trusted Internet Connection (TIC).

Office of Investigations (OI). Over the years, investments in OIG's Office of Investigations have yielded an excellent return for the government. In addition to civil and criminal convictions, OI cases frequently produce both financial settlements for institutional fraud and compliance agreements aimed at strengthening internal controls and systems to better protect federal funding in the future.

Since the beginning of FY 2013, OI has sustained a loss of seven FTEs, or 18 percent of its investigative staff, due to attrition. Recent budgetary restrictions have precluded replacement of all but two of these FTEs, until early FY 2015 when OI was able to hire two additional investigators. Funding at the Request Level will enable OI to continue to rebuild its civil criminal unit by supporting the addition of one special agent and one forensic IT specialist to use technical expertise in support of OIG investigations. Such services would include: applying electronic review of data to participation in searches conducted pursuant to statutory law enforcement authority; mirroring computers seized in the conduct of such searches; and providing testimony concerning the seizures and analysis of such evidence. It is estimated that additional funding for these two positions will enable OIG to conduct 40 more investigations during FY 2016. Further, OIG anticipates far more robust forensic investigations with an appropriately trained and qualified forensic investigator.

The vacancies that have occurred over the past two years have affected operations in several ways. First, in order to address those investigations that are currently open, OI has had to increase the number of active cases carried by each criminal and research misconduct investigator by 20 percent. This has resulted in delays in completing investigations, presenting cases to U.S. Attorneys for prosecution, and presenting reports of investigations to NSF to facilitate resolution of personnel misconduct and systemic weaknesses identified. Second, staff shortages have delayed development and implementation of the OI electronic case management system, eLOC. Due to the necessity of using an investigator to serve as subject matter expert and procurement development advisor for this initiative, other investigators have assumed a greater load of investigative duties.

Third, unfilled vacancies combined with the lack of travel funds have caused OI to reduce preventive activities and its very successful proactive review program. In the past, these efforts surfaced potential problems associated with individuals, institutions, and entities. Our identification of such problems at an early stage allowed us to bring systemic weaknesses to NSF and make recommendations to the agency regarding their correction. Finally, operating with reduced investigative staff has required, and will continue to require, that OI be more selective in the issues pursued to full investigation in an effort to conserve resources. While performance measured in terms of recoveries and funds put-to-better-use remains high, OI's ability to maintain that momentum over time depends on the adequacy of funding.

Budget cuts have also impaired efforts to address the continuing increase in financial frauds within the SBIR/STTR programs, an area of special Congressional concern. OIG opened 22 new SBIR investigations in calendar year 2011, 33 in 2012, 20 in 2013, and 19 in 2014, with the decline caused by the lack of available investigative staff. The establishment of the SBIR Investigative Working Group opened an effective dialogue within the OIG community about the pursuit of SBIR fraud, resulting in a

higher profile for such cases and numerous joint investigations. Our office has helped lead this multi-agency effort since its inception and sustaining a high level of commitment has been a top priority. Adequate investigative resources will be needed to return to the level of momentum generated during the first years of this initiative.

Office of Administration and Legal, Legislative and External Affairs (LLE). The Office of Legal, Legislative, and External Affairs (LLE) was created in FY 2012 under the executive leadership of an Assistant Inspector General (AIG). LLE consolidates a number of functions that have historically worked together, but which were aligned directly under the Inspector General -- legal, legislative/congressional, and external affairs (including public/media contacts). The LLE staff also actively supports government-wide projects in which NSF OIG has taken a leadership role, including those focused on increasing the use and effectiveness of suspension and debarment remedies to protect taxpayer funds and preventing and detecting fraud, waste, and abuse in the SBIR Program.

The staff and responsibilities for the Office of Administration were merged into LLE upon the retirement of the Deputy IG (who supervised the Office of Administration) in May 2013. The AIG LLE assumed responsibility for both operating units, and the position of Deputy IG will remain vacant for the foreseeable future. Administration is charged with performing strategic planning/budgeting, procurement, human resources, and office administration and is currently comprised of three staff. Combining the two units has saved money and provided synergistic benefits to the organization, but comes at a cost as one senior executive now assumes the many roles and responsibilities that were previously handled by two.

To ensure that there are adequate resources available for its core mission of audits and investigations, OIG support functions such as LLE and Administration have been streamlined to the maximum extent practical. On an interim basis, attorneys working within Investigations have assisted LLE to assure a basic level of office-wide legal support, which is largely reactive in nature. The AIG LLE must also personally handle a number of staff-level legal actions and questions, in addition to managing his expanded portfolio of responsibilities. In order to ensure that all of OIG's legal priorities are covered, LLE hired an Assistant Counsel in early FY 2015 to support the AIG in addressing the legal issues that arise. This addition will also enable the office to engage in proactive efforts (such as training and routine reviews) to recognize and deal with legal concerns as early as possible.

Preventive initiatives. Funding at the Request Level will enable OIG to strengthen its preventive initiatives program which has borne the brunt of recent budget cuts. OIG was forced to reduce many of its initiatives aimed at fulfilling its core mission to prevent fraud, waste, and abuse. These include efforts to address 1) growing concerns regarding the erosion of research integrity, as evidenced by a threefold increase in allegations in the past decade and studies indicating that 25 to 30 percent of scientists engage in questionable research practices; 2) the issues underlying the increasing number of allegations of serious misconduct under investigation which are related to the employment of scientists from other countries who may not understand U.S. rules and procedures; and 3) the underlying causes of SBIR program fraud. In the past, staff has played a key role in educating the agency's stakeholders, drawing on extensive experience in dealing with grant fraud and research misconduct. OIG's proactive efforts are consistent with the emphasis on transparency and accountability mandated by the Administration and the Congress and help assure the integrity of federally-funded research by promoting effective oversight of NSF-funded activities.

As previously noted, the proactive review program has been very productive in generating substantive new cases and identifying systemic problems that are discussed in Management Implication Reports and referred to NSF for corrective action. In recent years, the proactive program has gained access to powerful database analysis tools used to increase the number of fraud investigations undertaken by OIG

and allowing it to identify prospective NSF awardees that are high-risk recipients of federal funds based on past misconduct. However, recent budget constraints have prevented OIG from taking full advantage of this opportunity to leverage its investigative assets, improve its case production, and proactively identify systemic weaknesses.

OIG's ability to continue a robust preventive program of proactive investigative reviews and effective outreach depends on whether staffing and travel resources provide sufficient support, especially in light of other urgent audit and investigative priorities, as set out above. The direct interaction with the research community by OIG staff not only helps educate the community on how to maintain research integrity and financial accountability, but it also establishes vital channels of communication that provide investigators and auditors with valuable information and insights into the needs and concerns of institutions and researchers.

Finally, along with the progress OIG has made in the use of data analytics to strengthen its audits of awardee institutions goes a responsibility to share information about this new technology with the research community and other federal agencies. Outreach efforts aim to educate institutions about the advanced analytics employed and provide insight on system and audit support requirements necessary to complete the engagements in a timely and effective manner. At outreach events OIG also discusses how institutions can perform data analytics using software and financial applications already at their disposal to improve business intelligence and assure accountability for federal funds. In addition, many federal audit offices have expressed interest in learning about and introducing analytics in their own programs to surface additional risks. OIG has complied with these requests as resources allow and anticipates a continuing need for our support.

MAJOR MULTI-USER RESEARCH FACILITIES

Major Multi-user Research Facilities Funding

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Total Research and Related Activities	**$977.26**	**$973.01**	**$1,001.78**	**$28.77**	**3.0%**
Operations and Maintenance of Existing Facilities	745.41	717.00	737.91	20.91	2.9%
Federally Funded Research and Development Centers	199.51	207.01	202.83	-4.18	-2.0%
Operations and Maintenance of Facilities Under Construction	23.89	45.00	55.04	10.04	22.3%
R&RA Planning and Concept Development	8.45	4.00	6.00	2.00	50.0%
Major Research Equipment and Facilities Construction	**$200.00**	**$200.76**	**$200.31**	**-$0.44**	**-0.2%**
Total, Major Multi-User Research Facilities	**$1,177.26**	**$1,173.77**	**$1,202.09**	**$28.33**	**2.4%**

Totals may not add due to rounding.

NSF investments provide state-of-the-art tools for research and education, such as multi-user research facilities, distributed instrumentation networks and arrays, accelerators, telescopes, research vessels, aircraft, and earthquake simulators. In addition, investments in internet-based and distributed user facilities are increasing as a result of rapid advances in computer, information, and communication technologies. NSF's investments are coordinated with those of other organizations, agencies, and countries to ensure complementarity and integration. Planning, operations, and maintenance of multi-user facilities are funded through the Research and Related Activities (R&RA) account, and most major construction projects are funded through the Major Research Equipment and Facilities Construction (MREFC) account.

This chapter provides descriptions of each major multi-user research facility supported through the R&RA account and provides funding information by life cycle phase for each facility. The information presented for each facility follows the overall framework established by NSF for large facility projects. Information on projects under construction funded through NSF's MREFC account is provided in the MREFC chapter.

Major Multi-User Research Facilities Funding By Project

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Change over FY 2015 Estimate Percent
Operations and Maintenance of Existing Facilities	**$745.41**	**$717.00**	**$737.91**	**-$1.99**	**-0.3%**
Engineering					
National Nanotechnology Infrastructure Network (NNIN)	15.30	-	-	-	N/A
National Nanotechnology Coordinated Infrastructure (NNCI)	-	15.46	15.46	-	-
George E. Brown Jr. Network for Earthquake Engineering Simulation (NEES)	18.14	-	-	-	N/A
Natural Hazards Engineering Research Infrastructure (NHERI)	-	12.00	12.50	0.50	4.2%
Geosciences					
Academic Research Fleet[1]	83.00	85.00	85.00	-	-
Geodesy Advancing Geosciences and EarthScope (GAGE)	11.58	11.58	12.33	0.75	6.5%
International Ocean Discovery Program (IODP)	50.00	48.00	48.00	-	-
Ocean Observatories Initiative (OOI)[2]	49.30	55.00	55.00	-	-
Polar Facilities and Logistics	310.00	295.47	302.90	7.43	2.5%
Seismological Facilities for the Advancement of Geosciences and EarthScope (SAGE)	24.35	24.35	25.10	0.75	3.1%
Mathematical and Physical Sciences					
Arecibo Observatory	8.00	8.00	8.20	0.20	2.5%
Cornell High Energy Synchrotron Source (CHESS)	20.04	20.00	20.00	-	-
Gemini Observatory	19.58	20.61	19.77	-0.84	-4.1%
IceCube	6.90	6.90	6.90	-	-
Large Hadron Collider (LHC)	17.37	18.00	18.00	-	-
Laser Interferometer Gravitational-Wave Observatory (LIGO)	36.43	39.43	39.43	-	-
National High Magnetic Field Laboratory (NHMFL)	42.26	24.04	34.66	10.62	44.2%
National Solar Observatory (NSO)[3]	8.00	8.00	9.50	1.50	18.8%
National Superconducting Cyclotron Laboratory (NSCL)	22.50	22.50	22.50	-	-
Other Facilities[4]	2.66	2.66	2.66	-	-
Federally Funded Research and Development Centers[5]	**$199.51**	**$207.01**	**$202.83**	**-$4.18**	**-2.0%**
National Center for Atmospheric Research (NCAR)	96.60	98.20	99.00	0.80	0.8%
National Optical Astronomy Observatory (NOAO)	25.50	25.50	21.75	-3.75	-14.7%
National Radio Astronomy Observatory (NRAO)[6]	77.41	83.31	82.08	-1.23	-1.5%
Operations and Maintenance of Facilities under Construction	**$23.89**	**$45.00**	**$55.04**	**$10.04**	**22.3%**
Daniel K. Inouye Solar Telescope (DKIST)[7]	2.00	7.00	11.00	4.00	57.1%
National Ecological Observatory Network (NEON)	21.89	38.00	44.04	6.04	15.9%
R&RA Planning and Concept Development	**$8.45**	**$4.00**	**$6.00**	**$2.00**	**50.0%**
Pre-construction Planning[8]	1.86	4.00	6.00	2.00	50.0%
Concept and Development for MREFC Projects	6.59	-	-	-	N/A
Major Research Equipment and Facilities Construction	**$200.00**	**$200.76**	**$200.31**	**-$0.45**	**-0.2%**
Total, Major Multi-User Research Facilities	**$1,177.26**	**$1,173.77**	**$1,202.09**	**$28.32**	**2.4%**

Totals may not add due to rounding.

[1] An additional $1.86 million in FY 2014, $2.0 million in FY 2015, and $3.0 million in FY 2016 for Research Class Regional Vessels (RCRV) is included in pre-construction planning.

[2] OOI transitioned from MREFC construction to operations and maintenance phase in FY 2015 and thus is now included in the GEO Facilities section.

[3] The total presented does not include $5.0 million in FY 2015 and $9.0 million in FY 2016 for operations and maintenance support for the DKIST facility construction project. That funding is captured within the total presented on the DKIST line under Operations and Maintenance of Facilities under Construction.

[4] Other Facilities includes support for other materials research facilities.

[5] Federally-Funded R&D Centers do not include support for the Science and Technology Policy Institute (STPI), which is an FFRDC but not a multi-user research facility.

[6] Operations and maintenance of the Atacama Large Millimeter Array (ALMA) are included in NRAO.

[7] Of the total DKIST funding presented, $5.0 million in FY 2015 and $9.0 million in FY 2016 is for operations and maintenance support provided through the National Solar Observatory, and for all years, $2.0 million is for cultural mitigation activities as agreed to during the environmental compliance process. For more information, see the DKIST narrative in the MREFC chapter.

[8] Pre-construction planning includes R&RA funding for potential next-generation major multi-user facilities, including RCRV and Antarctic Infrastructure Modernization for Science (AIMS).

NSF Facilities Investments in FY 2016

The following pages contain information on NSF's ongoing facilities in FY 2016.

ACADEMIC RESEARCH FLEET

$88,000,000
+$1,000,000 / 1.1%

Academic Research Fleet
(Dollars in Millions)

FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Percent
$84.86	$87.00	$88.00	$1.00	1.1%

The U.S. Academic Research Fleet includes 20 vessels in calendar year 2014, and 19 vessels in calendar year 2015. These vessels range in size, endurance, and capabilities, enabling NSF and other federally funded scientists to conduct ocean science research with a diverse fleet capable of operating in coastal and open ocean waters. Funding for the Fleet includes investments in ship operations; shipboard scientific support equipment; oceanographic instrumentation and technical services; and submersible support. Funding levels reported here reflect investments in the Directorate of Geosciences (GEO) by the Division of Ocean Sciences (OCE). In addition to operations, OCE has undertaken selected construction projects based on inter-agency planning and coordination as discussed in the *Federal Oceanographic Fleet Status Report* published in May 2013.

Total Obligations for the Academic Research Fleet
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	ESTIMATES[1] FY 2017	FY 2018	FY 2019	FY 2020	FY 2021
Operations & Maintenance	$83.00	$85.00	$85.00	$85.00	$85.00	$85.00	$85.00	$85.00
RV Sikuliaq O&M[2]	*2.00*	*3.50*	*5.00*	*5.00*	*5.00*	*5.00*	*5.00*	*5.00*
Fleet Modernization	-	-	-	-	-	-	-	-
Regional Class Research Vessel	1.86	2.00	3.00	1.00	-	-	-	-
Total, Academic Research Fleet	**$84.86**	**$87.00**	**$88.00**	**$86.00**	**$85.00**	**$85.00**	**$85.00**	**$85.00**

Totals may not add due to rounding.

[1] Outyear funding estimates are for planning purposes only.

[2] As discussed in the R/V *Sikuliaq* narrative, operations and maintenance for the RV *Sikuliaq* are now included in Fleet Operations and Maintenance. Because the Academic Fleet is operated as a shared multi-agency resource where agencies pay for time uses on vessels, the annual OCE operating budget for any single vessel may vary significantly from year to year. Thus, estimates for the RV *Sikuliaq* for FY 2015 and beyond are provided as a rough guide of likely costs.

The U.S. Academic Research Fleet serves as the main platform for the collection of data and testing of hypotheses about the structure and dynamics of the ocean. Scientists contribute to advances in many areas including climate variability, marine ecosystems, fisheries, and ocean-related natural hazards, such as tsunamis, through use of these facilities. Participating graduate and undergraduate students interact with scientists and marine technicians, enabling them to gain first-hand exposure to ocean science field research. Increasingly, technological innovations allow research conducted at sea to be transmitted via satellite back to the classroom, broadening the educational impact of the vessels.

The Fleet is supported through an interagency partnership, principally with the Office of Naval Research (ONR) and the National Oceanic and Atmospheric Administration (NOAA). The operating costs for the Fleet are divided proportionally among the vessel users based on usage; NSF supports approximately 60 percent of the total, which includes the Ocean Observatories Initiative's use of the Fleet. NSF coordinates with ship-operating and ship-user academic institutions both directly and through the University National

Oceanographic Laboratory System (UNOLS) organizational structure.

Support for scientists using the Fleet is provided by both NSF and other federal and state agencies. Within NSF, science is funded through competitive peer-reviewed proposals, most typically funded within OCE and through selected programs in the Division of Earth Sciences (EAR), the Division of Atmospheric and Geospace Sciences (AGS), the Division of Polar Programs (PLR), and the Directorate for Biological Sciences (BIO). Approximately 25 percent of OCE proposals request ship time. Not reflected in this number is the science that utilizes samples or data collected on prior cruises, scientists piggy-backing on scheduled cruises to accomplish additional science, international scientists sailing with the U.S. Academic Research Fleet, and science funded by other agencies.

The FY 2016 Request of $88.0 million will support approximately 2,100 ship operating days.

Fleet Operations/Management and Oversight

- Oversight: NSF provides oversight to the Academic Research Fleet through cooperative agreements with each ship-operating institution and through a separate cooperative agreement with the UNOLS Office. NSF is the cognizant agency for ship operations rate negotiations. In addition, NSF oversees the Fleet through site visits, ship inspections, and participation at UNOLS Council and Committee meetings by NSF program directors. Several program directors within OCE at NSF, at NOAA, and at ONR are involved in the activities and oversight of the Academic Research Fleet. No Business System Reviews of Academic Research Fleet operating institutions are currently scheduled for 2015.
- Management: Management of an institution's ship-operating facilities varies with the scale of the operation, but the core responsibility typically resides with the Director of the Institution, the Marine Superintendent (for all aspects of the facility), and the Ship's Captain (for at-sea operations). For larger multi-ship-operating institutions, a Chief of Marine Technicians, schedulers, and finance administrators may also be involved in facility management.
- Reviews: Based on projected science requirements identified in recent reports and workshops, a fleet of vessels supporting ocean science research will be needed far into the future. Documents supporting this need include the *National Ocean Policy* and the *Final Recommendations of the Interagency Ocean Policy Task Force* of July 19, 2010. Two applicable reports by the National Research Council (NRC) include *Science at Sea: Meeting Future Oceanographic Goals with a Robust Academic Research Fleet* published in 2009, and *Critical Infrastructure for Ocean Research and Societal Needs in 2030* published in 2011. In coordination with UNOLS and the other federal agencies which invest in ocean research, the Interagency Working Group on Facilities and Infrastructure (IWG-FI) published a *Federal Oceanographic Fleet Status Report* in May 2013, reviewing the status and describing plans for modernizing the federal and academic oceanographic research and survey fleet. Ship operations and technical services proposals undergo external review by peers every five years. Detailed annual reports describing activities accomplished are provided by the operating institutions and budgets are negotiated yearly since they are dependent on the number of days the ships will be at sea in support of NSF-funded research programs.

Fleet Modernization

Oversight: The NSF coordinator for Fleet modernization activities is the Program Director for Ship Acquisition and Upgrades, within the Integrative Programs Section (IPS) in OCE, with additional IPS staff providing project management assistance as required.

Regional Class Research Vessel (RCRV): In March 2012, NSF leadership approved the request to advance the RCRV to the Conceptual Design Review (CDR) phase as a candidate Major Research Equipment and Facilities Construction (MREFC) project. On February 1, 2013, NSF made an award to Oregon State University (OSU) as the lead institution for advancement to CDR. Funds for CDR were provided from the Research and Related Activities account. In December 2013, OSU successfully

completed all CDR requirements in accordance with NSF's Large Facilities Manual. Approval for advancement to the Preliminary Design Phase was provided in March 2014. The Preliminary Design Review (PDR) was held in August 2014. The PDR Panel recommended the project be approved to advance to the Final Design Phase. Construction could start as early as FY 2017, contingent on continued satisfactory progress by the awardee, the project's consistency with overall NSF goals and strategic direction, and the availability of funds. Management and oversight would be similar to the R/V *Sikuliaq* project. NSF is continuing discussions with the NOAA Office of Marine and Aviation Operations to explore the potential for collaboration between the two agencies on the design of the RCRV and the modernization efforts being considered for the NOAA mid-size vessels. In addition, NSF is an active participant in the IWG-FI Ship Subcommittee, which developed the update to the 2013 *Federal Oceanographic Fleet Status Report*, an action in the *National Ocean Policy (NOP) Implementation Strategy.*[1] The RCRV would address requirements across the government agencies for research vessels in support of ocean science research as discussed in the Fleet Status Report Update. Decisions on proceeding to further development stages will be based upon NSF, National Science Board (NSB), and interagency reviews.

R/V *Sikuliaq*, formerly the Alaska Region Research Vessel (ARRV): The Research Vessel *Sikuliaq* represents NSF's first major contribution to Fleet renewal in over twenty years. Construction of the *Sikuliaq* was funded through the MREFC account, partially with American Recovery and Reinvestment Act (ARRA) funds. The project is led by the University of Alaska, Fairbanks (UAF) with engineering support from design through construction provided by UAF's naval architect, The Glosten Associates, Inc. Shipyard construction began in early 2011 and the vessel was successfully launched in October 2012. Delivery of the *Sikuliaq* to UAF took place in June 2014. This was followed by a period of final outfitting, science trials, and transit to the first science operational area. Initial science operations began in late 2014. Activities remaining in the construction portion of the project include ice trials to be conducted in the Bering Sea in 2015 and warranty items closeout, including the warranty dry docking inspection.

Research in the Arctic is needed on topics ranging from climate change, ocean circulation, ecosystem studies, and fisheries research, to natural hazards and cultural anthropology. The *Sikuliaq* will provide a sophisticated and significantly larger platform for scientists, as well as graduate and undergraduate students to participate in complex multidisciplinary research activities and will enable the training of the next generation of scientists with the latest equipment and technology. The *Sikuliaq* is expected to greatly expand research capabilities in the Arctic with up to 270-300 science days at sea annually. The ice-strengthened hull will allow the vessel to operate in seasonal ice up to one meter thick and an anti-roll tank will permit it to operate effectively in the open waters of the Bering Sea, Gulf of Alaska, and North Atlantic. Due to its size and projected operating area, the *Sikuliaq* will operate as a Global Class vessel within the U.S. Academic Research Fleet.

Other Ongoing Activities

Major overhaul and upgrade to the submersible Human Occupied Vehicle *ALVIN* was completed in FY 2013. The *ALVIN* Upgrade Project is scoped in two phases. Phase I was the integration of a new titanium 6,500-meter-capable personnel sphere with existing *ALVIN* vehicle components. Phase I completion provided a maximum depth capability of 4,500 meters, the limit of the legacy *ALVIN* components retained during Phase I. Phase II would provide upgrades to permit operations to a depth of 6,500 meters, but there has been no implicit or explicit commitment to proceed with Phase II at this time. Sea trials for operation of the Phase I vehicle in November 2013 supported certification for operations to

[1] www.whitehouse.gov/administration/eop/oceans/implementationplan

3,800 meters, and approximately 100 dives in support of science were made in 2014. Further sea trials to support certification to 4,500 meters are scheduled for January 2015.

Renewal/Re-competition/Termination

Ships supported by NSF are operated by academic institutions, each having a cooperative agreement with NSF. All ship cooperative agreements were renewed in FY 2012 using the NSB-approved criteria and review by an external panel. Awardees are subject to additional oversight measures, including quarterly safety and financial reporting, the use of NSF BSRs, and site inspections. In 2013, NSF retired *R/V Cape Hatteras*, operated by a consortium of Duke University and the University of North Carolina from its homeport at the Duke University Marine Laboratory. In 2014, NSF retired *R/V Point Sur*, operated by Moss Landing Marine Laboratories, San Jose University. For the *R/V Sikuliaq*, a re-compete clause in 10 years (2024) was included in the initial cooperative agreement for operations.

ARECIBO OBSERVATORY

$8,200,000
+$200,000 / 2.5%

Arecibo Observatory
(Dollars in Millions)

FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Percent
$8.00	$8.00	$8.20	$0.20	2.5%

The Arecibo Observatory (Arecibo), formerly the National Astronomy and Ionosphere Center, is a center for multidisciplinary research and education enabled by world-class observational facilities. The observatory's principal facility is the world's largest single-dish radio/radar telescope, a 305-meter diameter reflector located near the town of Arecibo in western Puerto Rico on 120 acres of U.S. Government-owned land. Arecibo is currently operated and managed by SRI International and subawardees Universities Space Research Association (USRA) and Universidad Metropolitana (UMET) under a cooperative agreement with NSF that began on October 1, 2011. The observatory serves over 350 users annually with a wide range of research and observing instrumentation in passive radio astronomy, solar system radar astronomy, and space and atmospheric sciences. A peer-review telescope allocation committee provides merit-based telescope time to users. The committee is common to the three fields, but specific topic experts from outside the observatory are consulted for reviews. NSF does not provide awards targeted specifically for use of Arecibo, although many users are supported through NSF or NASA grants to pursue scientific programs that require use of the facility.

Arecibo has a staff of about 122 full-time-equivalent positions at the beginning of FY 2015. A total of 97 permanent staff work for Arecibo. This includes 15 scientists who, along with engineers, technicians, and operators, are available to help visiting investigators with observing programs. In addition, there are management, administrative, and clerical positions, as well as maintenance staff, and several postdoctoral scholars and students. There are 25 individuals involved at the Angel Ramos Foundation Visitor Center, including 18 temporary tour guides.

Total Obligations for the Arecibo Observatory
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	ESTIMATES[1] FY 2017	FY 2018	FY 2019	FY 2020	FY 2021
Operations & Maintenance (MPS)	$4.50	$4.00	$4.10	$4.10	$4.10	$4.10	$4.10	$4.10
Operations & Maintenance (GEO)	3.50	4.00	4.10	4.10	4.10	4.10	4.10	4.10
Total, Arecibo	**$8.00**	**$8.00**	**$8.20**	**$8.20**	**$8.20**	**$8.20**	**$8.20**	**$8.20**

Totals may not add due to rounding.

[1] Outyear funding estimates are for planning purposes only. The current cooperative agreement ends in September 2016.

Arecibo is jointly supported by the NSF Directorate for Mathematical and Physical Sciences, Division of Astronomical Sciences (MPS/AST) and the NSF Directorate for Geosciences, Division of Atmospheric and Geospace Sciences (GEO/AGS). Planned AST support through FY 2016 is based upon the 2006 AST Senior Review recommendations, guidance from a third-party cost review of AST facilities, and a third-party estimate of Arecibo's non-scientific costs. Based on Senior Review recommendations, AST has been ramping down support for Arecibo. At the same time AGS has significantly increased support, with funding proposed to ramp up to parity with AST in FY 2015 and beyond. (More on AGS activities at Arecibo can be found below under Management and Oversight.)

In 2010, the National Research Council (NRC) conducted its sixth decadal survey in astronomy and astrophysics. In their report, *New Worlds, New Horizons in Astronomy and Astrophysics*, the NRC committee recommended that "NSF-Astronomy should complete its next senior review before the mid-decade independent review that is recommended in this report, so as to determine which, if any, facilities NSF-AST should cease to support in order to release funds for (1) the construction and ongoing operation of new telescopes and instruments and (2) the science analysis needed to capitalize on the results from existing and future facilities." In response to this recommendation, AST conducted a community-based review of its portfolio. The resulting Portfolio Review Committee (PRC) report, *Advancing Astronomy in the Coming Decade: Opportunities and Challenges,*[2] was released in August 2012 and included recommendations about all of the major AST telescope facilities.

The PRC recommended that support for Arecibo should be continued at funding levels near those currently planned, with a re-evaluation later in the decade, based on science opportunities and budget forecasts at that time. These re-evaluation timescales are roughly coincident with the expiration of the cooperative agreement at the end of FY 2016. In view of the long lead time required for conducting a management competition, NSF has contracted a feasibility study for divestment alternatives, which will provide a baseline structural and environmental survey of conditions at Arecibo. This study, to be completed in FY 2015, is likely to be followed by a formal review to evaluate environmental impacts of viable divestment options, including the possible impacts of potential partnerships.

Partnerships and Other Funding Sources: Arecibo leverages NSF support with funding from other federal and non-federal sources. Since FY 2010, the NASA Near Earth Object Observation Program has committed $2.0 million annually to Arecibo in support of the planetary radar program; this was increased to $3.60 million for FY 2013, with more observing time allocated to the NASA Program. NASA support is expected to continue at the level of about $3.70 million in FY 2015 and FY 2016, subject to the availability of funds. A grant to the Visitor Center from the Puerto Rico Department of Education was finalized in 2013. This award was for $1.90 million over seven months; part of this was to train teachers, as described in the next section, while part of it was to enable larger numbers of Puerto Rican school children to visit the site.

An aerial image of the Arecibo Radio Telescope in Puerto Rico. The platform suspension structure, including the Gregorian dome that houses the main suite of research instruments, is visible over the 305-meter primary reflector dish below. *Credit: Arecibo Observatory/NSF.*

Education and Public Outreach (EPO): Arecibo hosts a Research Experiences for Undergraduates (REU) site, and Ph.D. students receive training through the use of the facility. In collaboration with the National Radio Astronomy Observatory (NRAO), Arecibo holds a summer school on single-dish radio astronomy techniques. Arecibo also sponsors a major outreach program in Puerto Rico via the Angel Ramos Foundation Visitor Center as well as summer workshops for K-12 teachers. This center attracts more than 80,000 visitors each year; over 1.4 million people have visited since its opening in 1997. Approximately 25 percent of these visitors are K-12 students. With the funds mentioned above from the Puerto Rico Department of Education, Arecibo hosted three teacher workshops which trained a total of 428 teachers. This program integrates formal activities at the Angel Ramos Foundation Visitor Center

[2] www.nsf.gov/mps/ast/ast_portfolio_review.jsp

into the STEM curriculum in Puerto Rico. Arecibo also hosts several meetings each year within a wide variety of scientific disciplines.

Operations and Maintenance: Arecibo administers observing time to the astronomy and aeronomy communities via competitive observing proposals and conducts educational and public outreach programs at all levels. Observing hours among science programs are based on the quality of the observing proposals; the current average oversubscription rate of the telescope is approximately 3.5, counting ongoing astronomy surveys, new astronomy projects, solar system observations, and atmospheric sciences programs. About 80 percent of astronomy users conduct their observing remotely via networked control software, while radar observations typically employ on-site users.

In January 2014, a magnitude 6.4 earthquake off the coast of Puerto Rico damaged one of the cables supporting the platform structure high above the main dish. As a safety measure, the platform was not moved until structural repairs could be effectuated, requiring a significant modification to the telescope's operational plans and schedule. Repairs were completed, and the telescope returned to full service on March 11, 2014. During this unscheduled maintenance period, a formal pulsar drift scan program was able to effectively use the telescope.

Management and Oversight

- MPS/AST, $4.10 million: AST funds basic operations costs and science programs in passive radio astronomy and solar system radar astronomy. As recommended by the 2006 AST Senior Review, funding for Arecibo has been gradually reduced, declining to a lower baseline of $4.0 million in FY 2015. The modest increase in FY 2016 is a planned inflationary adjustment that was part of the baseline published in the solicitation for the Arecibo management competition carried out in FY 2010 and FY 2011. Arecibo operational scope has changed in response to decreased AST support. AST is currently determining its plan for support of Arecibo beyond FY 2016.
- GEO/AGS, $4.10 million: The incoherent scatter radar at Arecibo is part of an NSF-supported network of radars strategically distributed to observe the transport of radiative energy and charged particles, from their origins at the sun to their deposition in Earth's upper atmosphere. The unique sensitivity of the Arecibo incoherent scatter radar system allows it to measure the density, temperature, and motion of plasma in Earth's ionosphere with unrivaled time and spatial resolution. Arecibo is also the only aeronomy observatory located at tropical mid-latitudes, where many important ionospheric processes take place. An ionospheric high-frequency heating facility is currently under construction at Arecibo with completion anticipated in FY 2015. This heating facility is part of an expanded scope in aeronomy funded by AGS.
- NSF Structure: Ongoing oversight is provided by the lead NSF program officer in AST, in close cooperation with an assigned program officer in AGS and in consultation with community representatives. The program officers make use of detailed annual program plans, long range plans, quarterly technical and financial reports, and annual reports submitted to NSF by SRI. They also attend SRI governance committee meetings, as appropriate. To address issues as they arise, the program officers work closely with other offices at NSF, particularly the Division of Acquisition and Cooperative Support; the Office of General Counsel; and the Large Facilities Office of the Office of Budget, Finance, and Award Management. The AST and AGS program officers conduct periodic site visits and frequent teleconferences.
- External Structure: Management is via a cooperative agreement with SRI and its sub-awardees, USRA and UMET. The awardees provide management and oversight through their own advisory and visiting committees, including an Arecibo Observatory Users Committee, a Scientific Management Advisory Committee, a Council of Puerto Rican Chancellors and Stakeholders, and an Executive Governing Committee. The Arecibo director, resident at the telescope site, is the principal investigator of the operations award for the facility. Three deputy directors in the areas of

Atmospheric Sciences, Planetary Radar, and Puerto Rican EPO report to the Arecibo director.

- Reviews:
  - A review of the proposal for management and operations of Arecibo was held in 2010, resulting in an award to SRI (see below) from October 2011 to September 2016.
  - A Business Systems Review involving two of the partner organizations of Arecibo, SRI and UMET, was conducted in late 2012.
  - AST and AGS jointly conduct annual external reviews of Arecibo program plans; the most recent review was held in October 2013. The next program review will be held in late CY 2015. (A program plan review was not held in 2014, but was instead superceded by the mid-term management review: see next bullet below).
  - AST and AGS jointly conducted a mid-term management review of the Arecibo cooperative agreement in November 2014. The panel report is expected to be received early in calendar year 2015.

Renewal/Competition/Termination

The current cooperative agreement with SRI for the management of Arecibo was awarded on October 1, 2011, when SRI succeeded the previous managing organization, Cornell University. This followed a competitive process for a new five-year cooperative agreement, consistent with National Science Board policy. This agreement is in effect through September 30, 2016. The direction beyond that time will be determined after carrying out the study of divestment alternatives discussed above.

CORNELL HIGH ENERGY SYNCHROTRON SOURCE

$20,000,000
$0 / 0.0%

Cornell High Energy Synchrotron Source

(Dollars in Millions)

FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Percent
$20.04	$20.00	$20.00	-	-

The Cornell High Energy Synchrotron Source (CHESS) is a high-intensity, high-energy X-ray user facility supported by NSF with interagency support from the National Institutes of Health (NIH). It uses synchrotron light given off by charged particles, both electrons and positrons, as they circulate in a ring at nearly the speed of light. CHESS provides capabilities for X-ray research in physics, chemistry, biology, materials, and environmental sciences. Areas of emphasis include soft matter and thin film studies, solution scattering, nanomaterials, high-pressure science, structural biology, time-resolved studies of materials, and X-ray studies of structural materials. Stewardship and oversight of CHESS is provided through the NSF Division of Materials Research within the Directorate for Mathematical and Physical Sciences (MPS/DMR), as well as the Directorates for Biological Sciences (BIO) and Engineering (ENG).

The FY 2016 Request supports operations of CHESS as a national user facility and is consistent with funding levels in previous years. Support for CHESS has shifted over the past years from research and development to a national user facility, thus the activities are evolving. Funding will allow continued operation of the facility in support of high energy X-ray synchrotron users.

Total Obligations for CHESS

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	ESTIMATES[1] FY 2017	FY 2018	FY 2019	FY 2020	FY 2021
Operations & Maintenance (MPS)	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00
Operations & Maintenance (BIO)	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Operations & Maintenance (ENG)	5.04	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Total, CHESS	**$20.04**	**$20.00**	**$20.00**	**$20.00**	**$20.00**	**$20.00**	**$20.00**	**$20.00**

Totals may not add due to rounding.

[1] Outyear funding estimates are for planning purposes only. The current cooperative agreement ends in March 2019.

CHESS is a national user facility accessed on the basis of competitive proposal review. The primary function of CHESS staff is to maintain and operate the facility and to assist users. Users number about 750 annually and perform a broad array of research including: computationally-enabled scattering studies of complex materials; an analysis of the structure of designer solids including the impact of processing; enabling the engineering of materials through time-resolved synchrotron radiation studies, x-ray imaging, and spectroscopic studies; studying structural materials under operating conditions; and the analyses of macromolecules and biochemistry. The latter is done in collaboration with NIH. An annual users' meeting and several workshops help disseminate results from the facility.

- CHESS supports users from academia, industry, and national laboratories. CHESS is developing a dynamic testing station for structural materials through collaboration with the U.S. Air Force Research Laboratory and the Office of Naval Research. CHESS collaborates with DOE-supported synchrotron facilities such as the Advanced Photon Source and the National Synchrotron Light Source. X-ray detectors developed at CHESS are now in use at 3rd and 4th Generation X-ray sources around

the world, including the world's first hard X-ray laser, the Department of Energy's (DOE) Linear Coherent Light Source. CHESS-developed undulators, that cost an order of magnitude less than current technology, are being installed at CHESS. The undulators will increase X-ray flux by an order of magnitude and enable CHESS to pursue time-resolved and high resolution imaging experiments not previously possible. The Cornell undulators and other innovations such as high flux X-ray optic are impacting synchrotrons science world-wide.

- CHESS researchers also developed a new Kolsky bar apparatus to study the impact on structure of high strain rates using in situ diffraction from metals undergoing shock-wave induced strain. This unique capability uses the high flux of CHESS in combination with a new high speed pixel array detector. Understanding high impact deformation is particularly important to the automotive and aerospace industries.

CHESS supports and enhances Ph.D. level graduate education, postdoctoral research, and research experiences for undergraduates and for K-12 students and science teachers. Their education and outreach program annually impacts over 6,000 people of all ages, including over 1,300 visitors touring the Cornell facilities. Each year there are about 60 Ph.D. degrees granted as a result of CHESS research. CHESS is a key training ground for X-ray and accelerator scientists, with CHESS graduates being hired to staff other X-ray facilities in the U.S. and around the world.

Management and Oversight

- NSF Structure: CHESS is supported by Directorate for Mathematical and Physical Science (MPS), Engineering (ENG), and Biological Sciences (BIO) through a cooperative agreement with Cornell University. The MPS Division of Materials Research (MPS/DMR) program director is the primary contact with the facility, and leads an internal NSF team of program directors. Additional support for CHESS operations is provided by NIH.
- External structure: CHESS is administered by the Cornell Laboratory of Accelerator-based Sciences and Education (CLASSE), which reports to Cornell's Vice-Provost for Research. The principal investigator serves as the CHESS director and reports to the Director of CLASSE. The CHESS director receives guidance primarily from the CHESS executive committee, from an external policy and advisory board, the CHESS diversity committee, and the users' executive committee.
- Reviews: NSF provides oversight by monitoring annual plans and reports including user metrics, as well as by conducting monthly phone conferences with the director. The NSF uses annual site visit reviews to assess the user program, in-house research, long-term plans to contribute significant research developments both nationally and internationally, and operations, maintenance, and facility development. Annual reviews also assess the status of education training and outreach, operations and management efficiency, and diversity plans. In addition to a panel of experts from the community, representatives from the NIH attend these site visits. Recent and upcoming reviews include:
  - A Management Review focusing on CHESS operations and strategic planning was held July 9-10, 2014.
  - The next annual site visit review will be held in the fall of 2015.

Renewal/Recompetition/Termination

A comprehensive renewal review was conducted in FY 2013 for a five year renewal award covering the period April 1, 2014 – March 31, 2019.

GEMINI OBSERVATORY

$19,770,000
-$840,000 / -4.1%

Gemini Observatory

(Dollars in Millions)

FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Percent
$19.58	$20.61	$19.77	-$0.84	-4.1%

The Gemini Observatory consists of twin optical/infrared 8-meter telescopes, one each in the northern and southern hemispheres. Gemini North sits atop Mauna Kea, Hawaii at 4,200 meters elevation, while Gemini South is located on the 2,700 meter summit of Cerro Pachón, Chile. This siting of the two telescopes provides complete coverage of the sky and complements observations from space-based observatories. Both telescopes offer superb image quality and employ sophisticated adaptive optics technology to compensate for the blurring effects of the Earth's atmosphere.

Among the fundamental questions being investigated by today's astronomers are the age and rate of expansion of the universe, the origin of the "dark energy" that is manifested in the cosmic acceleration, the nature of non-luminous matter, the processes that give rise to the formation and evolving structures of galaxies, and the formation of stars and planetary systems. The current generation of large optical/infrared telescopes is central to these studies, owing to their unsurpassed sensitivity and spectral and spatial resolution. Technological advances incorporated into the design of the Gemini telescopes optimize their imaging capabilities and infrared performance as well as their ability to rapidly reconfigure the attached instrumentation in response to changing atmospheric conditions.

Night at the Gemini North telescope on Mauna Kea, Hawaii. The transparent-dome effect is created by the stacking of many images obtained throughout a night of observing. The central regions of our Milky Way galaxy seen against an incredibly dark sky provide a stunning backdrop to the telescope. *Credit: Gemini Observatory/AURA.*

The Gemini telescopes help educate and train U.S. astronomy and engineering students. An estimated 10 percent of the roughly 500 U.S. users per year are students. Gemini also provides an engaging focal point for public outreach and student training in all of the partner countries, and maintains "sister city" arrangements between the site hosts of Hilo, Hawaii and La Serena, Chile. Gemini-sponsored activities attract students and teachers at all levels of elementary through high school education. Gemini staff members provide guidance and support to the Imiloa Science Center, a public astronomy and cultural center in Hilo, Hawaii.

Total Obligations for the Gemini Observatory

(Dollars in Millions)

				ESTIMATES[1]				
	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021
Operations & Maintenance	$19.58	$20.61	$19.77	$20.61	$20.61	$20.69	$21.28	$21.89

[1] Outyear funding estimates are for planning purposes only. The current cooperative agreement ends on December 31, 2015.

The international partnership that operates Gemini currently consists of the U.S., Canada, Australia, Brazil, Argentina, and Chile, with the U.S. as the majority partner. Construction of the telescopes and their instrumentation involved a large number of industrial entities in these and other countries, with areas of specialization that included large and/or complex optical systems, engineering, electronics, electro-mechanical systems, and computing, among others. Continued development in these technological areas is reflected in the instrumentation and facilities renewal activities that are incorporated into the overall budget of the Gemini Observatory.

Laser guide star systems, which greatly improve the ability to correct for atmospheric blurring, are available at both facilities. The advanced "multi-conjugate" adaptive optics system on Gemini South continues to lead the world with near-infrared images that exceed the quality available with orbiting observatories and offer a wider field of view than is provided by any competing system. Commissioned during the past year and now in regular use for directly imaging and characterizing planets orbiting nearby stars is the state-of-the-art Gemini Planet Imager, while improvements to the multi-object spectrograph in Chile have greatly increased its utility in the far red spectral region.

The U.S. share of Gemini Observatory observing time is open to proposals by any researcher in the U.S. astronomical community, with peer-review allocation committees providing merit-based telescope time. NSF does not provide awards targeted specifically for use of Gemini. However, U.S. users are often supported through separate NSF research awards to pursue scientific programs that require the use of the observatory.

In 2010, the National Research Council (NRC) conducted its sixth decadal survey in astronomy and astrophysics. In their report, *New Worlds, New Horizons in Astronomy and Astrophysics*,[3] the NRC committee recommended that "NSF-Astronomy should complete its next senior review before the mid-decade independent review that is recommended in this report, so as to determine which, if any, facilities NSF-AST should cease to support in order to release funds for (1) the construction and ongoing operation of new telescopes and instruments and (2) the science analysis needed to capitalize on the results from existing and future facilities." In response to this recommendation, the Division of Astronomical Sciences (AST) conducted a community-based review of its portfolio. The resulting Portfolio Review Committee (PRC) report, *Advancing Astronomy in the Coming Decade: Opportunities and Challenges*[4] was released in August 2012 and included recommendations about all of the major AST telescope facilities.

The PRC report ranked Gemini Observatory as a critical component of our Nation's future astronomical research resources and recommended that the U.S. retain a majority share in the international partnership for at least the next several years. However, given the constraints that were considered, the Committee recommended that the maximum U.S. contribution to Gemini operations in 2017 and beyond should be

[3] www.nap.edu/catalog.php?record_id=12951
[4] www.nsf.gov/mps/ast/ast_portfolio_review.jsp

$17.0 million per year. Given the withdrawal of the United Kingdom and Australia from the Gemini partnership (see below), and the NRC recommendation that the U.S. increase its partner share in Gemini, the budget request for Gemini remains somewhat higher than that recommended by the PRC.

The FY 2016 Request includes the full U.S. contribution to baseline operations at the level agreed to by the international partners ($18.02 million in FY 2016), and a contribution of $1.75 million to the Gemini Instrument Development Fund. Future requirements are being considered in the context of NSF's overall actions on the 2012 Portfolio Review recommendations and discussion of the post-2015 international agreement with Gemini partners; these considerations are likely to change the out-year funding estimates slightly.

Management and Oversight

- NSF Structure: NSF has one seat on the Gemini Board, currently occupied by the division director of the Directorate for Mathematical and Physical Sciences/Division of Astronomy (MPS/AST). An additional NSF staff member serves as the executive secretary to the board. Programmatic oversight is the responsibility of an NSF program officer in MPS/AST. The program officer monitors operations and development activities at the observatory, nominates U.S. scientists to Gemini advisory committees, conducts reviews on behalf of the partnership, and approves funding actions, reports, and contracts.
- External Structure: The observatory is governed by the Gemini Board, established by the International Gemini Agreement signed by the participating agencies. NSF serves as the executive agency for the partnership, carrying out the project on their behalf. The U.S. holds six of the 13 seats on the Gemini Board, and NSF appoints the five non-NSF members. In FY 2013, NSF appointed the Director of the U.S. National Optical Astronomy Observatory (NOAO) as one of these members in order to facilitate increased cooperation between NOAO and Gemini and to provide an improved voice for the general U.S. astronomical community. Gemini is currently managed by the Association of Universities for Research in Astronomy (AURA), Inc., on behalf of the partnership through a cooperative agreement with NSF. AURA conducts its own management reviews through standing oversight committees.
- Reviews: NSF conducts periodic reviews of the management and observatory programs as requested by the Gemini Board. The most recent mid-term management review was held in September 2008. NSF conducted a Business System Review (BSR) of the observatory in March 2009, and several other AURA facilities, including its centralized administrative services, were the subject of a BSR in 2013. The current cooperative agreement to AURA for the operation of Gemini was awarded after a renewal proposal review in March 2011 and extends through December 31, 2015.

Renewal/Recompetition/Termination

The United Kingdom withdrew from the Gemini partnership at the end of 2012 in the midst of a major restructuring of that country's scientific priorities. This required the observatory to adjust its operations model to an approximately 24 percent reduction in budget, which will result in a reduction in total staffing from about 200 in FY 2011 to less than 160 by the end of FY 2017. More recently, Australia, a 6.3 percent partner, has declared that it is unable to commit to a specific funding level beyond 2015, but wishes to move to a more limited participation on a year-to-year basis. Discussions with a new potential international partner have progressed rapidly during the past year and arrangements are now being made for that group to assume the full 6.3 percent share of Australia in FY 2017. The technical contents of a new international agreement for the post-2015 years have been agreed on among the partners, but any further delays in formal signature of the agreement by the governments could have significant impact on the partnership and the NSF budget..

The current NSF cooperative agreement to AURA for managing the Gemini Observatory includes the transition to the new operations model. Reductions in project scope that accompany the decline in budget

include a reduced instrument complement on each telescope, a reduction in labor for the scheduling queue, decreased development and outreach activities, and a tighter operational focus on serving the partner user communities vs. internal scientific research activities. The funding recommendation for this plan was approved by the National Science Board in February 2012.

In order to provide the most competitive atmosphere for managing Gemini after the end of the current cooperative agreement in December 2015, NSF postponed issuance of a solicitation for proposals until summer 2014. This delay moved the Gemini solicitation beyond the timeframe for the other major U.S. optical observatory, NOAO. Delaying the Gemini solicitation necessitated a one-year extension of the current Gemini cooperative agreement with AURA until December 2016, an action that has been described to the National Science Board and which entails a review now underway. Proposals for the ensuing competed agreement for managing the observatory are due February 27, 2015. Review of those proposals will lead to an award that is targeted to take effect January 1, 2017 and will cover a six-year period through December 31, 2022.

GEODESY ADVANCING GEOSCIENCES AND EARTHSCOPE $12,330,000
+$750,000 / 6.5%

Geodesy Advancing Geosciences and EarthScope

(Dollars in Millions)

FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Change over FY 2015 Estimate Percent
$11.58	$11.58	$12.33	$0.75	6.5%

The Geodesy Advancing Geosciences and EarthScope (GAGE) comprise a distributed, multi-user, national facility for the development, deployment, and operational support of modern geodetic instrumentation to serve national goals in basic research and education in the Earth sciences with a focus on studies of Earth's surface deformation at many scales with unprecedented temporal and spatial resolution. GAGE facilities support fundamental research and discovery on continental deformation, plate boundary processes, the earthquake cycle, the geometry and dynamics of magmatic systems, continental groundwater storage, and hydrologic loading. GAGE is managed and operated for NSF by UNAVCO, Inc., a consortium of 107 U.S. universities and non-profit institutions with research and teaching programs in geophysics and geodesy and 93 associate members from foreign institutions. GAGE was formed in late FY 2013 from part of the EarthScope program and UNAVCO. In FY 2016, a small increase is requested to allow GAGE to continue providing service to the community consistent with that in previous years.

Total Obligations for GAGE

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	ESTIMATES[1] FY 2017	FY 2018	FY 2019	FY 2020	FY 2021
Operations & Maintenance	$11.58	$11.58	$12.33	$12.33	$12.33	$12.33	$12.33	$12.33

Totals may not add due to rounding.

[1] Outyear funding estimates are for planning purposes only. The current cooperative agreement ends September 30, 2018.

The ability to determine position with respect to a well-constrained terrestrial reference frame using space geodetic techniques has, over the last three decades, improved to submillimeter capability. Space geodesy applications are extremely broad and expanding to include important societal research on earthquake and tsunami hazards, volcanic eruptions, hurricanes, coastal subsidence, wetlands health, soil moisture, groundwater distribution, and space weather. Applications of geodetic techniques to understanding the complex interplay between climate dynamics, continental ice sheet and mountain glacier dynamics, crustal isostatic adjustments, and sea level change is of foremost relevance to current global issues confronting humanity.

To serve the research needs of the broad Earth science community, GAGE is organized under three primary service areas and two special emphasis areas:

Geodetic Infrastructure

- The EarthScope Plate Boundary Observatory (PBO) includes more than 1,100 continuous Global Positioning System (GPS) stations (430 of which transmit data in real-time) distributed across the United States, and concentrated on the active plate boundaries in the western contiguous U.S. and southern Alaska. PBO also includes 75 borehole strainmeters and 78 borehole seismometers

deployed along the San Andreas Fault and above the Cascadia subduction zone and volcanic arc. Tiltmeters (25) and pore pressure sensors (23) are also collocated with the other borehole instruments.

- Global GPS Arrays outside of the PBO footprint are supported by GAGE in partnership with investigators. Nearly 600 continuous GPS observations from around the world are maintained, monitored, and data compiled into the GAGE data system. GAGE supports 62 of the over 250 GPS sites in the National Aeronautics and Space Administration (NASA)-supported Global Navigation Satellite System (GNSS) array that supports satellite orbit and clock corrections and the refinement of the International Terrestrial Reference Frame (ITRF). GAGE is also supporting the development of data distribution systems for a > 100 station Caribbean region GPS and meteorological sensor network (COCONet) to support tectonic, volcano, tropical storm, and sea level change investigations.
- Community GPS receiver and geodetic technology pool includes a pool of over 650 GPS receivers, ancillary equipment, and six terrestrial laser scanners (TLS), which can be used by investigators for short- and long-term deployments on qualified research projects.
- Polar Networks supports GAGE's polar GPS networks in Antarctica (ANET) and Greenland (GNET) and development of specialized GPS monumentation, power, and telemetry solutions for use in harsh environments. GAGE also provides portable campaign deployment geodetic instrumentation, training, and field support for experiments in the polar regions. Additional supplemental funding for these activities is provided through the Division of Polar Programs (PLR).
- Investigator Project Support includes project management, field engineering, and technical support services to plan and execute GPS surveys and permanent station installations. GAGE also maintains a staff focused on geodetic technology equipment testing services to evaluate new geodetic technologies and improve performance for science applications.

Geodetic Data Services

- Geodetic Data Services manages an archive of over 140 terabytes of GPS, laser scanning, Synthetic Aperture Radar (SAR) and borehole geophysical instruments from all GAGE components including EarthScope PBO, global continuous GPS networks, and campaign GPS observations; operates automated and manual systems to ensure the quality of all data stored in the archive; and provides systems to give the national and international research community timely access to these data. The archive of SAR imagery maintained and distributed by GAGE to support interferometric SAR imagery of continuous surface deformation at scales of 100s to 1,000 km is complementary to discrete GPS measurement of displacement. As the U.S. currently has no civilian spaceborne SAR sensor, UNAVCO, as the manager of GAGE, brokers for cost-effective community access to the SAR imagery acquired by foreign SAR satellite systems.

Education and Community Engagement

- The GAGE Education and Community Outreach (ECE) Program enables audiences beyond geodesists to access and use geodetic data and research for educational purposes, including technical short courses, student internships, web-based materials, and programs for strengthening workforce development and improving diversity in the geosciences.

Special Emphasis Areas

- Community Activities include scientific and technical workshops that bring together the international seismic community and publications designed to communicate GAGE activities and results to the community.
- External Affairs maintains outreach efforts to policymakers and planning for coordination with the international geodesy community.

Besides its role in providing the observational data essential for basic Earth science research, GAGE also plays a significant role providing geodetic infrastructure support to NASA investigators and the

international community through activities in maintaining a subset of the Global GNSS Network (GGN); which supports the refinement of the ITRF and corrections to satellite orbits and clocks, all contributing to the capability for millimeter-level geodetic positioning, subtle observations of Earth's time-varying gravity field and detection of annual millimeter-level changes in sea level.

Commercial surveyors and engineering firms download GAGE facility real-time GPS data daily to support precision positioning. The economic impact of this service to the commercial sector has not been quantified, but is likely substantial.

Management and Oversight

- NSF Structure: The Division of Earth Sciences (EAR), through its Instrumentation & Facilities program (IF), provides general oversight of GAGE to help assure effective performance and administration. The program also facilitates coordination of GAGE programs and projects with other NSF-supported facilities and projects, and with other federal agencies, and evaluates and reviews the performance of UNAVCO in managing and operating GAGE. The Deep Earth Processes section head and division director in EAR provide other internal oversight.
- External Structure: GAGE is managed and operated by UNAVCO, which is incorporated as a non-profit consortium representing 107 U.S. universities and non-profit organizations with research and teaching programs that rely on geodetic technologies for Earth Science research. Each voting Member Institution of the Consortium appoints a Member Representative, and these Member Representatives elect the nine members of the UNAVCO Board of Directors, seven of which are drawn from member institutions, and two Directors-at-Large. The Board members, who serve two-year terms, vet all internal program decisions associated with GAGE management and operation, through consultation with UNAVCO staff and GAGE advisory committees (one for each major GAGE component and additional *ad hoc* working groups appointed for special tasks). The Board of Directors appoints a president of UNAVCO to a renewable two-year term. The president is responsible for UNAVCO operations, all of which are managed through the UNAVCO Corporate Headquarters in Boulder, Colorado.
- Reviews: All major ongoing geoscience facilities routinely undergo mid-award reviews of their management, in addition to peer review of proposals for new or continued support. The formal NSF merit review of the five-year proposal for the GAGE facility took place in 2012 and 2013 and was also the most recent review of UNAVCO. Although the *ad hoc* reviewers and two independent review panels had a number of specific recommendations at the working level for GAGE, overall the review found that GAGE was a critical facility for U.S. and international Earth sciences. Furthermore, the reviewers found that UNAVCO is a well-managed and effective organization that has, through its commitment to the collection and open dissemination of the highest quality geodetic data, transformed the discipline of geodesy and its geoscience applications.

Renewal/Recompetition/Termination

The initial cooperative agreement for GAGE began October 1, 2013, and will expire September 30, 2018. In FY 2017, in keeping with the phased integration and recompetition plan presented to the National Science Board in December 2009, NSF intends to solicit proposals for a future facility or facilities to support the Earth sciences research and education community currently supported by GAGE and the related Seismological Facilities for the Advancement of Geoscience and EarthScope (SAGE). NSF is currently considering the precise form of this solicitation, and any possible future facility/facilities are currently being considered within NSF and through discussions with the GAGE and SAGE support communities.

ICECUBE NEUTRINO OBSERVATORY

$6,900,000
$0 / 0.0%

IceCube Neutrino Observatory

(Dollars in Millions)

FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Percent
$6.90	$6.90	$6.90	-	-

IceCube is the world's first high-energy neutrino observatory, located deep within the ice cap under the U.S. Amundsen-Scott South Pole Station in Antarctica. With the discovery in 2013 of the first neutrinos from beyond our solar system, the Observatory has demonstrated that it represents a new window on the Universe, providing unique data on the engines that power active galactic nuclei, the origin of high-energy cosmic rays, the nature of gamma ray bursts, the activities surrounding supermassive black holes, and other violent and energetic astrophysical processes. Approximately one cubic kilometer of ice is instrumented with photomultiplier (PM) tubes to detect neutrino-induced, charged reaction products produced when a high-energy neutrino interacts in the ice within or near the cubic kilometer fiducial volume. The energy and arrival direction of high-energy neutrinos ranging in energy from 100 GeV to 10 PeV (1 GeV is 109 electron Volts [eV]; 1TeV is 1012 eV; and 1 PeV is 1016 eV) are derived from the IceCube data stream. The IceCube Collaboration has studied neutrino events down to a deposited energy of 1 TeV. High-energy neutrinos may be produced either by the interaction of cosmic rays in the Earth's atmosphere, the so-called atmospheric neutrinos, or in the vicinity of distant astrophysical accelerators like black holes and neutron stars, the so-called astrophysical neutrinos. Astrophysical neutrinos remain the dominant component above 10 TeV.

The IceCube project has transformed one cubic kilometer of natural Antarctic ice into a particle detector. The sensors keep watch for momentary flashes of blue light made by subatomic particles called muons; some are produced in collisions of neutrinos with atomic nuclei inside or near the detector. Since completion in 2010, the IceCube detector has been taking data in its final configuration with an up-time of well over 99 percent. IceCube detects one neutrino every 6 minutes in a background of 2700 cosmic ray muons per second. To handle the high rates, initial analysis of the data is performed by a cluster of computers housed in a two-story building placed on top of the array. The filtered data is sent over geostationary satellites to the IceCube Research Center at the University of Wisconsin. *Credit: USAP Photo Library, Sven Lidstrom (sic), NSF.*

The Observatory includes a Deep Core Array (DCA) with tightly-spaced digital optical modules to detect lower energy neutrinos (down to about 10 GeV), thus opening the door to studies of neutrino oscillation measurements and studies of Weakly Interacting Massive Particles (WIMPs) below 250 GeV. In essence, the DCA closes the energy gap between the IceCube Neutrino Observatory and the Super-Kamiokande detector in Japan, and also allows effective observations of high-energy neutrinos entering from the sky of the southern hemisphere.

Total Obligations for IceCube
(Dollars in Millions)

	FY 2014	FY 2015	FY 2016	ESTIMATES[1]				
	Actual	Estimate	Request	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021
Operations & Maintenance (GEO)	$3.45	$3.45	$3.45	$3.45	$3.45	$3.45	$3.45	$3.45
Operations & Maintenance (MPS)	3.45	3.45	3.45	3.45	3.45	3.45	3.45	3.45
Total, IceCube	$6.90	$6.90	$6.90	$6.90	$6.90	$6.90	$6.90	$6.90

Totals may not add due to rounding.

[1] Outyear funding estimates are for planning purposes only. The current cooperative agreement ends on September 30, 2015.

The IceCube Neutrino Observatory is presently led by the University of Wisconsin (UW) and was constructed with support from four countries (U.S., Belgium, Germany, and Sweden). The science collaboration is much broader, currently consisting of 16 U.S. institutions and 22 institutions in nine other countries (Germany, Belgium, Sweden, New Zealand, Australia, Canada, Japan, Switzerland, and the United Kingdom). NSF's foreign partners contribute a *pro rata* share of operations and maintenance costs based on the number of PhD-level researchers involved.

Management and Oversight

- NSF Structure: Oversight of the IceCube Neutrino Observatory is the joint responsibility of the Geosciences Directorate's Division of Polar Programs (PLR) and the Mathematical and Physical Sciences Directorate's Division of Physics (PHY). Support for operations and maintenance, research, and education and outreach is shared by PLR and PHY, as well as other organizations and international partners. NSF provides oversight through regular site visits by NSF managers and external reviewers.
- External Structure: The UW management structure for IceCube includes leadership by the project's Principal Investigator supported by the Director of Operations and two associate directors (one for Science and Instrumentation and one for Education and Outreach). A Collaboration Spokesperson is selected from the senior international scientific leaders for one or two year terms. At lower levels, project management includes international collaboration representatives, as well as participation by staff at collaborating U.S. institutions. UW has in place an external Scientific Advisory Committee and a Software and Computing Advisory Panel that meet annually and provide written advice to the project. UW leadership, including the Chancellor, provides additional awardee-level oversight.
- Reviews: NSF will begin a process for re-competition of the operations and maintenance award in FY 2015. A new award is expected to be in place for FY 2016.

Operations Costs

Full operations and maintenance in support of scientific research began in FY 2011. The associated costs are and will continue to be shared by the partner funding agencies – U.S. (NSF) and non-U.S. – proportional to the number of PhD researchers involved (currently about 55:45). The current NSF award for operations and maintenance constitutes the bulk of the U.S. contribution to general operation of the facility. In addition, work in support of facility operations is performed by students, postdocs, and senior researchers who are participating in research on the data produced by the Observatory.

NSF support for U.S. institutions working on more refined and specific data analyses, data interpretation (theory support), and instrumentation upgrades is provided through the Research and Related Activities (R&RA) account in response to merit-reviewed proposals.

The general operations of South Pole Station, reported in the Polar Facilities and Logistics narrative, also contribute to supporting IceCube. The cost of IceCube operations shown in the table herein includes only those that are project-specific and incremental to general South Pole Station operations. The expected operational lifespan of the IceCube Neutrino Observatory is 25 years, beginning in FY 2011.

Education and Outreach

IceCube provides a vehicle for helping to achieve national and NSF education and outreach goals. Specific outcomes include the education and training of next-generation leaders in astrophysics, including undergraduate students, graduate students, and postdoctoral research associates; K-12 teacher scientific/professional development, including development of new inquiry-based learning materials and use of the South Pole environment to convey the excitement of astrophysics, and science generally, to K-12 students; increased opportunity for involvement of students in international collaborations; increased diversity in science through partnerships with minority institutions; and enhanced public understanding of science through broadcast media and museum exhibits (such as the Adler Planetarium) based on IceCube science and the South Pole environment. NSF supports evaluation and measurement-based education and outreach programs under separate grants to universities and other organizations that are selected following standard NSF merit review.

Renewal/Recompetition/Termination

A solicitation for re-competition, conducted in accordance with NSF policy, will be issued early in 2015. The present award, which expires in September 2015, may be extended to allow time for the competition process.

THE INTERNATIONAL OCEAN DISCOVERY PROGRAM

$48,000,000
$0 / 0.0%

International Ocean Discovery Program
(Dollars in Millions)

FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Percent
$50.00	$48.00	$48.00	-	-

The International Ocean Discovery Program (IODP) began in FY 2014 as the replacement for the Integrated Ocean Drilling Program and the prior Ocean Drilling Program. The new IODP represents an international partnership of the scientists, research institutions, and funding organizations of 26 nations to explore the evolution and structure of Earth as recorded in the ocean basins. The new program management structure is streamlined and focused on maximizing facility efficiency, while retaining the intellectual cooperation and exchange of the previous drilling programs. NSF, the Ministry of Education, Culture, Sport, Science and Technology (MEXT) of Japan, and the European Consortium for Ocean Research Drilling (ECORD) continue to provide drilling platforms. IODP platforms provide sediment and rock samples (cores); in-situ monitoring, sampling, and measurement from borehole observatories; shipboard and shore-based descriptive and analytical facilities; down-hole geophysical and geochemical measurements (logging); and opportunities to conduct experiments to determine in-situ conditions beneath the sea floor.

JOIDES Resolution underway for a science expedition, March 10, 2009. *Credit: NSF*

Total Obligations for IODP
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	ESTIMATES[1] FY 2017	FY 2018	FY 2019	FY 2020	FY 2021
Operations & Maintenance	$50.00	$48.00	$48.00	$48.00	$48.00	$48.00	$48.00	$48.00

Totals may not add due to rounding.

[1] Outyear funding estimates are for planning purposes only.

Annual operations and maintenance support for operating the *JOIDES Resolution*, the most-used IODP platform, represents NSF's primary contribution to the program. The *JOIDES Resolution* is leased from an offshore drilling contractor under a long-term contract. Another commercial contractor provides down-hole-logging services. Maintaining databases and core repositories, preparing scientific publications emerging from *JOIDES Resolution* IODP expeditions, and management of international program proposal review through an IODP Support Office represent additional NSF IODP science integration costs, made minimal to NSF because of international contributions to the program. In addition, NSF provides support for U.S. scientists to sail on IODP drilling platforms and to participate in IODP advisory panels through an associated grants program. The annual costs for the associated science integration and science support (not included in the table above) are approximately $8.0 million.

The new IODP scientific program includes emphasis on the following research themes:

- Climate and Ocean Change: Reading the Past, Informing the Future;
- Biosphere Frontiers: Deep Life, Biodiversity, and Environmental Forcing of Ecosystems;
- Earth Connections: Deep Processes and Their Impact on Earth's Surface Environment; and
- Earth in Motion: Processes and Hazards on Human Time Scales.

An umbrella IODP Forum provides a venue for all IODP entities to exchange ideas and views on the scientific progress of the program. In the simplified new IODP management structure, each drillship is governed by independent facility boards, each unique and optimized for their respective drilling platform. In the case of the *JOIDES Resolution* Facility Board (JRFB), two advisory panels review proposals and give science and safety advice. A U.S. scientist leads the JFRB, with other members from the scientific community, funding agencies, and the facility operator. The other IODP platforms utilize the JRFB advisory panels for drilling proposal review.

IODP participants include the United States, Japan, ECORD (Austria, Belgium, Canada, Denmark, Finland, France, Germany, Iceland, Ireland, Israel, Italy, the Netherlands, Norway, Poland, Portugal, Sweden, Switzerland, and the United Kingdom), Brazil, the People's Republic of China, Korea, India, Australia, and New Zealand, with all participants except Japan providing financial contributions to *JOIDES Resolution* operations. Japan provides program support through substantial investment in *Chikyu* operations, with U.S. and Japanese scientists enjoying reciprocal rights on each drilling vessel.

Over 3,400 scientists from 51 nations have participated on Ocean Drilling Program, Integrated Ocean Drilling Program, and International Ocean Discovery Program expeditions since 1985, including more than 1,450 U.S. scientists from over 150 universities, government agencies, and industrial research laboratories. Samples and data have been distributed to at least 1,000 additional U.S. scientists. Scientists from these groups propose and participate in IODP cruises, are members of the program's advisory panels and groups, and supply data for planning expeditions and interpretation of drilling results.

Management and Oversight

- NSF Structure: The Division of Ocean Sciences (OCE) in the Directorate for Geosciences (GEO) manages IODP operations of the *JOIDES Resolution* and the IODP Support Office under the NSF Ocean Drilling Program (ODP). NSF's ODP is located within the Integrative Programs section, with two program officers dedicated to its oversight. One of the program officers has responsibility for two cooperative agreements supporting *JOIDES Resolution* operations and the IODP Support Office, while the other oversees the NSF ODP grants program.
- External Structure: NSF provides the *JOIDES Resolution* as the light IODP drillship through a cooperative agreement with Texas A&M University. MEXT provides the *Chikyu* as the heavy IODP drillship through the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), while the British Geological Survey manages ECORD drilling contributions through single-use Mission-Specific Platforms. Each entity providing an IODP drilling platform is responsible for sample and data storage, publications, and other science costs associated with the respective platform operations.
- IODP *JOIDES Resolution* operations are determined by the JRFB, utilizing advice and recommendations provided by the Science Evaluation Panel (SEP) and the Environmental Protection and Safety Panel (EPSP). Representation on the panels is determined by contribution level to *JOIDES Resolution* operations and exchange with other facility boards.
- Reviews: Performance of the *JOIDES Resolution* facility will be reviewed by NSF panel yearly in consultation with the JRFB. Substantive review of management performance regarding *JOIDES Resolution* operations will occur in the third year of the cooperative agreement to guide renewal or re-competition decisions. Review of scientific progress in broader thematic areas is conducted under the authority of the IODP Forum.

Renewal/Recompetition/Termination

After competitive selection, Texas A&M University was selected in FY 2014 to be the *JOIDES Resolution* operator under a 5 year (FY15- FY19) cooperative agreement. This cooperative agreement contains language encouraging the awardee to facilitate novel partnerships involving support of *JOIDES Resolution* operations between the U.S. scientific drilling community and commercial industry, thereby providing new intellectual opportunities and potential reduction in overall facility cost.

In FY 2013, to facilitate and support the activities of U.S. scientists participating in IODP activities, an IODP Science Support Office was selected at the University of California, San Diego through a competitive process for a 5 year (FY 2014- FY 2018) cooperative agreement.

The *JOIDES Resolution* operations and science support cooperative agreements contain a provision for annual external review of performance by an independent panel. Intensive mid-award reviews will be conducted for both cooperative agreements and will consider whether they should be extended or re-competed.

LARGE HADRON COLLIDER

$18,000,000
$0 / 0.0%

Large Hadron Collider
(Dollars in Millions)

FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Percent
$17.37	$18.00	$18.00	-	-

The Large Hadron Collider (LHC), an international project at the CERN (the European Organization for Nuclear Research) laboratory in Geneva, Switzerland, is the most powerful particle accelerator ever constructed. It produces the highest energy particle beams ever created, making it the premier facility in the world for research in elementary particle physics. The LHC consists of a superconducting particle accelerator providing two counter-rotating beams of protons, approximately 16.5 miles in circumference, each beam with up to 7 TeV ($1TeV=10^{12}$ electron volts) of energy. It can also provide colliding beams of heavy ions, such as lead. Data-taking with colliding proton beams at 4 TeV ended in December 2012 at which point the LHC was reconfigured to deliver heavy ion collisions for six weeks. In March 2013, the LHC began a 20-month period of extensive repairs and enhancements that will enable it to operate at the full design energy of 7 TeV per beam, commencing in spring 2015.

Four large particle detectors collect the data delivered by the LHC. They characterize the reaction products produced in the high-energy proton-proton collisions and heavy ion beam collisions, which are analyzed to investigate the fundamental properties of matter. More than forty international funding agencies provide support for scientists to participate in experiments at the LHC and CERN is responsible for meeting the overall LHC project goals and coordinating international participation. The U.S., through a partnership between the Department of Energy (DOE) and NSF, made major contributions to the construction and operation of two of the largest particle detectors, a Toroidal LHC Apparatus (ATLAS) and the Compact Muon Solenoid (CMS), while NSF additionally supports a small number of researchers who participate in the LHC-b detector. During the 20-month maintenance period noted above, the detectors are also undergoing an extensive series of repairs and enhancements to prepare for resumed operation with more intense and higher energy beams (>6.5TeV/beam) during 2015-2018.

The successful operation during 2012 of the accelerator complex, the ATLAS and CMS detectors, and the world-wide LHC computing grid culminated in the first major discovery at the LHC. On July 4, 2012, the CMS and ATLAS collaborations announced the discovery of a particle consistent with the long-sought Higgs boson. Further study of the properties of this new particle suggest that it is probably the Higgs boson that is predicted in the Standard Model of particle physics, which provides a deeper understanding of the origin of mass of known elementary particles. This achievement was recognized by the 2013 Nobel Prize in Physics to Francois Englert and Peter Higgs for the "theoretical discovery of a mechanism that contributes to our understanding of the origin of mass." The LHC program includes searches for particles predicted by a powerful theoretical framework known as supersymmetry, which may provide clues as to how the known forces – weak, strong, electromagnetic, and gravitational – evolved from different aspects of the same "unified" force in the early universe. The resumed program of operation at higher energy and higher intensity planned to start in 2015 is expected to significantly enhance the chances of more ground-breaking discoveries at the LHC.

Total Obligations for LHC

(Dollars in Millions)

	FY2014 Actual	FY2015 Estimate	FY 2016 Request	ESTIMATES[1] FY 2017	FY 2018	FY 2019	FY 2020	FY 2021
Operations & Maintenance	$17.37	$18.00	$18.00	$20.00	$20.00	$20.00	$20.00	$20.00

[1] Outyear funding estimates are for planning purposes only. The current cooperative agreements end in December 2016 (CMS) and January 2017 (ATLAS).

A world-wide cyber-infrastructure, the LHC grid, is dedicated to LHC data processing, allowing scientists to remotely access and analyze vast data sets. The U.S. LHC collaboration continues to be a leader in the development and exploitation of distributed computing. The LHC grid, and the Tier 2 computing centers funded by NSF, enable U.S. universities to access LHC data and computing resources, and thus train students, in both state of the art science and computational techniques. The distributed computing tools and techniques developed for the LHC are expected to have broad application throughout the scientific and engineering communities.

In addition to preparing for resumed accelerator operation in 2015, experimenters have also commenced construction activities for a "Phase 1" upgrade of the detectors following the conclusion of 2015-2018 accelerator operation. The goals of this upgrade are primarily to repair expected radiation damage and to benefit from advances in detector technology while maintaining existing detector capabilities. The May 2014 report of the Particle Physics Project Prioritization Panel (P5) recommended to DOE and NSF that the highest priority strategic goal for U.S. particle physics within a global context should be continued support for involvement in the LHC program, including a further planned upgrade of the accelerator to very high luminosity operation, commencing in 2023. This would necessitate significant refurbishments and enhancements to the detectors in order to exploit this scientific opportunity. NSF has commissioned an advisory panel to seek community advice regarding how best to implement the P5 recommendations.

Through the participation of young investigators, graduate students, undergraduates, and minority institutions in this international project, LHC serves the goal of helping to produce a diverse, globally-oriented workforce of scientists and engineers. Innovative education and outreach activities allow high school teachers and students to participate in this project.

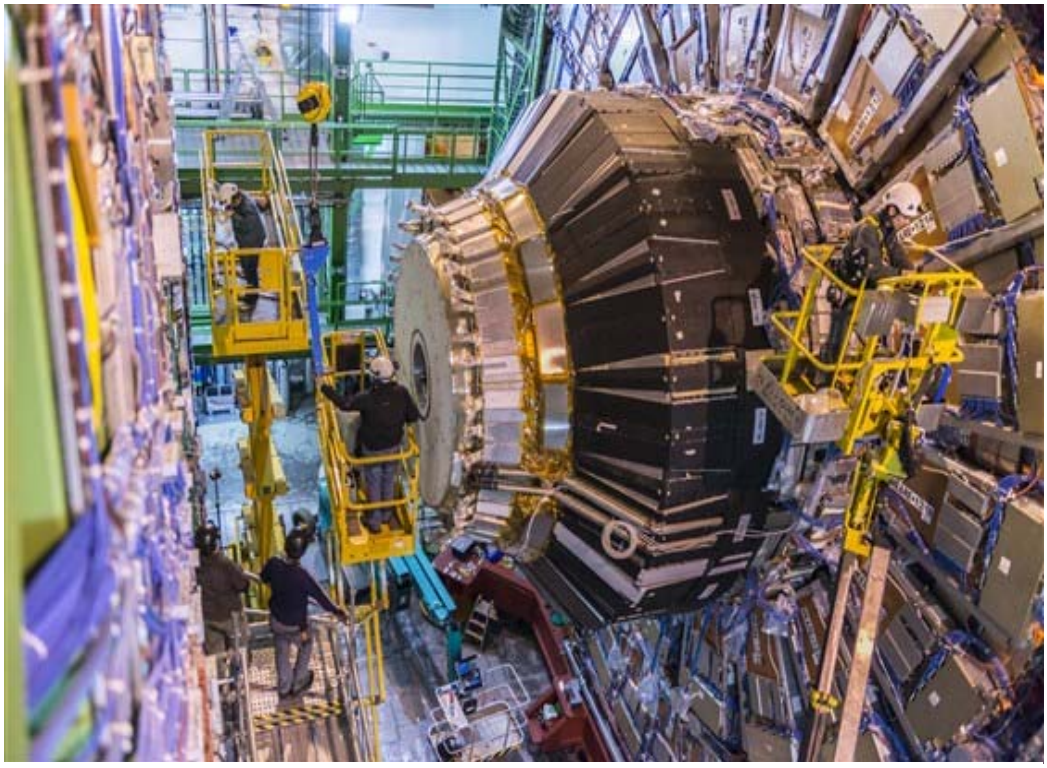
Management and Oversight

- NSF Structure: A program director in the Directorate for Mathematical and Physical Sciences, Division of Physics is responsible for day-to-day project oversight.
- External Structure: U.S. program management occurs through a Joint Oversight Group (JOG), created by NSF and DOE. The JOG has the responsibility to see that the U.S. LHC program is effectively managed and executed to meet commitments made under the LHC international agreement and its protocols. NSF operations support is provided through cooperative agreements with Princeton University for US-CMS and with Columbia University for ATLAS.
- Reviews: There is one major management/technical review each year with a panel of external, international experts, one minor follow-up review six months later, as well as bi-weekly telephone reviews by NSF/DOE program directors to monitor progress. NSF and DOE jointly conduct separate external reviews of the Phase 1 upgrade activities. The next major management/technical review is scheduled for April 2015. Two JOG review meetings per year monitor overall program management.

Renewal/Recompetition/Termination

The LHC project is expected to continue at least through the end of the next decade. In December 2011, new cooperative agreements were negotiated with the ATLAS and CMS collaborations to extend funding for five years to support their role in the international collaborations. It is anticipated that the U.S.

ATLAS and CMS collaborations will submit renewal proposals during 2016 for a continuation of support for five years beyond the current agreements, beginning in FY 2017.



CMS Detector undergoing maintenance in December 2013. *Credit: CERN.*

LASER INTERFEROMETER GRAVITATIONAL-WAVE OBSERVATORY — $39,430,000 / $0 / 0.0%

Laser Interferometer Gravitational-Wave Observatory
(Dollars in Millions)

FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Percent
$36.43	$39.43	$39.43	-	-

Einstein's theory of general relativity predicts that cataclysmic processes involving extremely dense objects in the universe, such as the collision and merger of two neutron stars or black holes, will produce gravitational radiation. Detection of these gravitational waves is of great importance for fundamental physics, astrophysics, and astronomy. The Laser Interferometer Gravitational-Wave Observatory (LIGO), the most sensitive gravitational-wave detector ever built, comprises two main facilities, one in Livingston Parish, LA and one in Hanford, WA. At each facility, a large vacuum chamber with two 4-km arms joined at right angles houses an optical interferometer. The interferometers are used to measure minute changes in the distances between mirrors at the ends of the arms caused by a passing gravitational wave. The predicted distortion of space caused by a gravitational wave from a likely source is on the order of one part in 10^{21}, meaning that the expected change over the apparent 4-km length is only on the order of 4×10^{-18} meters, or about 1/1000th the diameter of a proton. The 4-km length for LIGO, the largest for any optical interferometer, was chosen to make the expected signal as large as possible within terrestrial constraints. Looking for coincident signals from both interferometers simultaneously increases the likelihood for gravitational wave detection.

Components for a third interferometer, initially intended for installation at Hanford as a further tool to discriminate candidate signals from random noise, have been set aside in response to a proposed initiative from the Government of India to establish a gravitational wave observatory there. If realized, this third interferometer would, in addition to increasing noise immunity, greatly enhance LIGO's angular resolution of candidate gravitational wave sources, facilitating follow-up investigations using optical and radio telescopes.

In April 2008 construction began on the Advanced LIGO (AdvLIGO) Major Research Equipment and Facility Construction (MREFC) project, which is designed to increase the sensitivity of LIGO tenfold. AdvLIGO is being built within the existing LIGO observatory. LIGO's current and projected operations and maintenance expenses are designed to sustain operation of the LIGO laboratory while construction is underway, as well as to commission and operate the upgraded apparatus following the completion of construction in 2015. These include support for basic infrastructure costs not directly related to the AdvLIGO construction project, analysis and dissemination of data obtained from the

An aerial view of the Livingston, Louisiana LIGO site. *Credit: Caltech/MIT LIGO Laboratory.*

interferometers, maintenance of computational resources for data storage and analysis, complementary research and development expected to enhance operational performance and reduce technical risk, and education and outreach activities associated with the laboratory.

The LIGO Science Education Center at the Livingston site is the focal point for augmenting teacher education at Southern University and other student teacher activities state wide through the Louisiana Systematic Initiative Program. The LIGO Science Education Center's programs include funding for an external evaluation firm that provides both assistance in aligning future activities with proposed goals and evaluating outcomes.

In order to meet its cutting-edge performance requirements, substantial connections with industry have resulted from the undertaking of the AdvLIGO project. Innovations across a diverse range of technologies have led to new techniques with broad applications, and in other cases have resulted in patents and commercial products.

Total Obligations for LIGO

(Dollars in Millions)

	FY 2014	FY 2015	FY 2016	ESTIMATES[1]				
	Actual	Estimate	Request	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021
Operations & Maintenance	$36.43	$39.43	$39.43	$39.43	$39.43	$39.43	$39.43	$39.43

[1] Outyear funding estimates are for planning purposes only. The current cooperative agreement ends in FY 2018.

The LIGO Scientific Collaboration (LSC), an open collaboration that organizes the major international groups doing research supportive of LIGO, has more than 80 collaborating institutions in 15 countries with more than 900 participating scientists. The LSC plays a major role in many aspects of the LIGO effort, including establishing priorities for scientific operation, data analysis and validation of scientific results, and for instrumental improvements at the LIGO facilities, as well as fostering education and public outreach programs. NSF supports LSC activities at $7.0 to $8.0 million per year, which is provided through regular disciplinary program funds.

Installation of a quantum-mechanical squeezing experiment at LIGO in 2011. The temporary experiment allowed LIGO to increase its sensitivity by more than 20 percent over most of its frequency range. Such research is conducted by LIGO Laboratory and the LIGO Scientific Collaboration to reduce risk in the Advanced LIGO construction project. *Credit: Caltech/MIT LIGO Laboratory.*

The Advanced LIGO MREFC Project is expected to be substantially complete before April 2015. The LIGO Livingston Observatory interferometer has successfully demonstrated that it meets acceptance requirements for the completion of construction, and the LIGO Hanford Observatory is following closely behind. The first scientific operation of both interferometers is planned for the fall of 2015, as part of the overall plan to interleave engineering studies that tune up the detection sensitivity with periods of scientific operation intended to directly observe gravitational waves. Already, the LIGO Livingston Observatory has demonstrated robust operation with more than twice the sensitivity of the initial LIGO apparatus, and the 2015 run is planned at better than triple the initial LIGO sensitivity. By 2018, both interferometers are expected to operate at better than ten times the initial LIGO sensitivity.

Acting on the advice of an external review panel that assessed LIGO computing strategy, a no-cost extension of the Advanced LIGO MREFC project has been approved by NSF in order to enable the project to purchase computing hardware immediately prior to when it is needed in order to benefit from continuing technical innovation and price/performance advances. Consequently, the last computing purchases will be deferred until mid-2017.

Upon completion of the AdvLIGO construction stage in April 2015, LIGO operations will expand to encompass commissioning and operation of the new instrumentation. NSF has determined operating budget requirements by assessing cost data from initial LIGO interferometer operation and scaling appropriately to reflect the increased support that will be needed to support the more complex AdvLIGO apparatus.

Management and Oversight

- NSF Structure: NSF oversight is coordinated internally by the LIGO program director in the NSF Directorate for Mathematical and Physical Sciences, Division of Physics (MPS/PHY), who also chairs the PHY AdvLIGO Integrated Project Team (IPT), comprised of the Physics Division Director, MPS Facilities Coordinator, staff from the NSF Office of General Counsel, Office of Legislative and Public Affairs, International Science and Engineering, program directors from elsewhere in NSF, as well as the Large Facilities Office.
- External Structure: LIGO is managed by the California Institute of Technology under a cooperative agreement. The management plan specifies significant involvement by the user community, represented by the LSC, and collaboration with the other major gravitational-wave detector activities in Asia, Europe, and Australia. External peer-review committees organized by NSF help provide oversight through an annual review.
- Reviews after 2010:
  - AdvLIGO Annual Review, April 2011
  - LIGO Annual Review and AdvLIGO Interim Review, November 2011
  - LIGO Annual Review and AdvLIGO Interim Review, November 2012
  - LIGO Annual Review and AdvLIGO Interim Review, May 2013
  - LIGO Computing Review, May 2014
  - LIGO Annual Review and AdvLIGO Interim Review, June 2014
  - Additional reviews of LIGO operation and AdvLIGO construction are planned during 2015

Renewal/Recompetition/Termination

LIGO began operating under a new five-year cooperative agreement in early FY 2009. Following approval by the National Science Board in August 2013, the cooperative agreement was renewed at the beginning of FY 2014 for five additional years. As a condition of approval of this award (and a possible future award), the National Science Board stipulated that the operation of LIGO be recompeted no later than 2018. The projected lifetime of the LIGO facility was originally 20 years. Infrastructure refurbishments recently accomplished or planned during the current award will extend the facility life by an additional 15 to 20 years.

NATIONAL HIGH MAGNETIC FIELD LABORATORY $34,660,000
+$10,620,000 / 44.2%

National High Magnetic Field Laboratory
(Dollars in Millions)

FY 2014 Actual[1]	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Percent
$42.26	$24.04	$34.66	$10.62	44.2%

[1] Amount includes $9.63 million in forward funding from FY 2013 to FY 2014. This reduced the funding needed in FY 2015.

The National High Magnetic Field Laboratory (NHMFL) is operated by Florida State University (FSU), University of Florida (UF), and Los Alamos National Laboratory (LANL). NHMFL develops and operates high magnetic field facilities that scientists and engineers use for research in condensed matter and material physics, materials science and engineering, chemistry, biology, biochemistry, neuroscience, energy, and the environment. It is the world's premier high magnetic field laboratory with a comprehensive collection of high-performing magnet systems and extensive support services. The facilities are available to all qualified scientists and engineers through a peer-reviewed proposal process. Users number about 1,300 per year, including faculty and staff at the three host institutions.

The laboratory is an internationally recognized leader in magnet design, development, and construction, including the development of new superconducting materials. Many of the unique magnet systems were designed, developed, and built by the Magnet Science and Technology (MS&T) Division of NHMFL. Since 2012, the laboratory has held the world's record for the highest nondestructive, pulsed magnetic field at 100.75 tesla. The 45 tesla hybrid magnet currently provides the highest steady-state magnetic fields in the world. Both magnets enable scientists to get new insights into the electronic structures of novel materials such as graphene, topological insulators, high temperature superconductors, and more. MS&T works with industry and other international magnet laboratories on a variety of technology projects. These include design and construction of high field magnets, component development, coil fabrication, cryogenics, system integration, and testing.

A $15.0 million award funded by the American Recovery and Reinvestment Act of 2009 through the NSF Directorate for Mathematical and Physical Sciences, Division of Chemistry (MPS/CHE) enabled the purchase of a 21 tesla magnet for the construction of a Fourier Transform Ion Cyclotron Resonance Spectrometer (FT-ICR). The magnet was delivered in 2014. Once commissioning is completed in 2015, the FT-ICR will be unprecedented in sensitivity and selectivity. This instrument will be capable of analyzing chemical samples of great complexity, such as biological fluids, biofuels, and raw and weathered petroleum. This will impact areas such as chemistry, molecular biology, and earth science.

The FY 2016 Request will allow the facility to continue operations, focus on magnet development, and strengthen education, training, user support, and in-house research. A potential impact of this investment is the successful construction of an all superconducting magnet that would make high magnetic fields attainable at lower operating costs than current technology. This would open the door for many laboratories to access high magnetic fields and could be transformational in many research areas, particularly when combined with other probes such as X-rays, neutrons, or terahertz radiation. Another example of a potential breakthrough is in new imaging techniques for studying the brain. Currently Magnetic Resonance Imaging (MRI) and functional MRI have been based on imaging proton spin density and intrinsic tissue relaxation rates. With higher magnetic field strengths, NHMFL is pushing to use other nuclei. New insights into mapping the brain and neurochemistry may result.

Total Obligations for NHMFL

(Dollars in Millions)

	FY 2014 Actual[1]	FY 2015 Estimate	FY 2016 Request	ESTIMATES[2] FY 2017	FY 2018	FY 2019	FY 2020	FY 2021
Operations & Maintenance	$42.26	$24.04	$34.66	$35.78	$35.79	$35.79	$35.79	$35.79

[1] Amount includes $9.63 million in forward funding from FY 2013 to FY 2014. This reduced the amount needed in FY 2015.

[2] Outyear funding estimates are for planning purposes only. The current cooperative agreement ends in December 2017.

NHMFL collaborates with more than 60 private sector companies as well as national laboratories, including those supported by the Department of Energy (DOE), such as the Spallation Neutron Source and the Advanced Photon Source at Argonne National Laboratory. International collaboration is strong; NHMFL delivered and commissioned a 26 tesla series connected hybrid resistive/superconducting magnet to the Helmholtz-Zentrum Berlin (HZB), where it will be used for neutron scattering experiments. Collaborations also exist with the International Thermonuclear Experimental Reactor (ITER) in France, and national magnet labs in France, the Netherlands, Germany, and China.

NHMFL provides a unique interdisciplinary learning environment. The Center for Integrating Research and Learning at NHMFL conducts education and outreach activities, which include a Research Experience for Undergraduates (REU) program, summer programs for teachers, a summer camp for middle school girls, and activities to raise the scientific awareness of the general public.

Management and Oversight

- NSF Structure: NHMFL is supported by the MPS Division of Materials Research (MPS/DMR), with the DMR program director as the primary contact for most of the laboratory. The MPS Division of Chemistry (MPS/CHE) supports the Fourier Transform Ion Cyclotron Resonance (FT-ICR) Laboratory, which is overseen by a CHE program director.
- External Structure: A consortium of FSU, UF, and LANL operates NHMFL under a cooperative agreement. FSU, as the agreement signatory, is responsible for administrative and financial oversight and for ensuring that lab operations are consistent with the cooperative agreement. The principal investigator, the NHMFL director, reports to the FSU Vice President for Research. Four senior faculty members are co-principal investigators. The NHMFL director receives guidance primarily from the NHMFL executive committee, NHMFL science council, and NHMFL diversity committee and recommendations from an external advisory committee and the users' executive committee.
- Reviews: NSF monitors annual plans and reports including user metrics and conducts monthly teleconferences with the director. NSF conducts annual external reviews, which assess the user programs, in-house research, long-term plans to contribute significant research developments both nationally and internationally, and operations, maintenance, and new facility development. Annual reviews also assess the status of education training and outreach, operations and management efficiency, and diversity plans. Recent and upcoming reviews include:
  - Annual site review by external panel of site visitors, February 2014.
  - NSF initiated a community study through the National Research Council on opportunities in high magnetic field research. The 2013 report "High Magnetic Field Science and Its Application in the United States" was presented to the National Science Board in May 2014. Public town halls were held at several professional meetings by both DMR and CHE. The report will inform future plans for investments in this area.
  - Business Systems Review in December 2014 and January 2015.
  - Annual site review by external panel of site visitors, scheduled for June 3-4, 2015.

Renewal/Recompetition/Termination

A review was held in FY 2012 for a five year renewal award covering FY 2013 – FY 2017.

NATIONAL NANOTECHNOLOGY COORDINATED INFRASTRUCTURE

$15,460,000
$0 / 0.0%

National Nanotechnology Coordinated Infrastructure
(Dollars in Millions)

FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Percent
-	$15.46	$15.46	-	-

Over the past decade of its authorized award life, the National Nanotechnology Infrastructure Network (NNIN) has enabled major discoveries, innovations, and contributions to education and commerce. NNIN provided researchers from academia, small and large companies, and government with open access to university user facilities with leading-edge fabrication and characterization tools, instrumentation, and expertise within all disciplines of nanoscale science, engineering, and technology. In FY 2015, following a thorough process to seek input from the nanotechnology research community, NSF is moving forward with an open competition, NSF program solicitation 15-519, for a new National Nanotechnology Coordinated Infrastructure (NNCI) as the successor to NNIN. The competition for individual sites will consider large and small university-based user facilities, including those at minority-serving institutions, that are geographically distributed and with diverse and complementary capabilities to support current and anticipated future user needs across the broad spectrum of nanoscale science, engineering, and technology domains. A coordinating office will then be selected competitively at a later stage from among the selected sites to enhance their impact as a national infrastructure of user facility sites.

Total Obligations for NNCI
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	ESTIMATES[1] FY 2017	FY 2018	FY 2019	FY 2020	FY 2021
Operations & Maintenance	-	$15.46	$15.46	$15.46	$15.46	$15.46	$15.46	$15.46

[1] Outyear funding estimates are for planning purposes only. FY 2015 is the first year of funding for the program.

The selected individual sites will have autonomy in their operation and management, but will be required to act in concert with the coordinating office. Some sites may choose to partner with facilities at regional or smaller institutions that would bring specific capabilities for users and benefits to student training. The overall collection of selected sites and their capabilities will provide users with cost-effective access both to the specialized tools, processes, and expertise to support complex multi-step fabrication at the nanoscale level for structures, materials, devices, and systems, as well as to the associated instrumentation for characterization, analysis, and probing at these dimensions. The program aims to make these capabilities broadly available to the Nation's researchers in academia, industry, and government to help catalyze new discoveries in science and engineering and to stimulate technological innovation. The individual sites will support a rich user base with broad accessibility and affordable user fee structure. NSF funds will leverage those of university and other resources to grow the numbers of external users, including those from companies as well as from academia. Sites will embrace a culture of open access to researchers for any research project of merit, with protection of intellectual property, and mechanisms for encouraging non-traditional users from diverse disciplines. They will also have an organizational structure that allows coordination of complex process steps and tools for integrated tasks, and acceptance of experimental risks associated with non-standard processes and materials.

The broad spectrum of domain capabilities in this coordinated program is intended to encompass: physical-, chemical-, and biological-based nanostructures, materials, devices, and systems; electronic, optical, photonic, magnetic, mechanical, thermal, chemical, bioengineering, biomedical, and fluidic nanodevices and systems; nanoscale building blocks and nanostructured materials, composites, coatings, and surfaces; geophysical, geochemical, and environmental nanostructures and processes; synthetic biology, and fabrication in soft matter including biological interfaces; heterogeneous integration of complex, three-dimensional nanoscale systems to create new functionality; hierarchical design and fabrication to build nanoscale systems across multiple dimensional scales, including modeling and simulation tools that complement and support these activities; prototyping, process integration, and testing of manufacturing concepts, including high-speed roll-to-roll fabrication processes; and other areas, as appropriate.

Nanotechnology facilities provide unique opportunities to infuse innovative education with research at the frontiers of the field. Sites will provide focused strategies for integrating forefront science and engineering with education, including plans for assessing effectiveness and spreading promising practices. Sites having particular expertise in the social and ethical implications of nanotechnology will be encouraged to integrate study and dissemination of those aspects into their proposals that can leverage their user community base, which relate to the capabilities of their respective user facilities.

Management and Oversight

- NSF structure: Post-award oversight will be under the guidance of the NSF lead program officer and directorate working group members to monitor progress of the award and award accomplishments. This will consist of an annual review by a reverse site visit at NSF, although some on-site reviews, particularly for the larger funded sites, may be held. A Business Systems Review will be held once within the five-year period of the award. The awardees will submit comprehensive annual project reports to NSF in advance of each annual review. The annual project reports will contain a program plan and budget for the next-year's funding increment. Each annual review of a site will focus on the quality of performance and management under the cooperative agreement. Data collection will be consistent with NSF policies for information collection.

- External structure: A coordinating office (CO), to be located at one of the awarded institution sites, will be competed and chosen to provide the coordinating function. The CO director will be a key individual for developing management strategies and operational plans in concert with the site directors of the individual user facilities, and will serve as a principal contact person with NSF. The CO will be responsible for establishing a comprehensive web portal to ensure close linkages among the individual facility websites such that they present a unified face to the user community of overall capabilities, tools, and instrumentation. It will also work with all sites on methods to guide users regarding which site or sites, which instruments, and which processes would enable users to complete their projects most successfully. The CO will help to coordinate and disseminate best practices for national-level education and outreach programs across sites, as well as the study and dissemination of social and ethical implications of nanotechnology. It will seek to harmonize capabilities for modeling and simulation in nanoscale fabrication and characterization across sites, and provide effective coordination with the NSF-supported Network for Computational Nanotechnology (NCN). The CO will establish an external advisory board of distinguished members from academia, industry, and government to provide advice and guidance through the CO.

Renewal/Recompetition/Termination

- The National Nanotechnology Initiative (NNI) 2014 Strategic Plan emphasizes the importance and

critical need for the U.S. to sustain a dynamic infrastructure and toolset to advance nanotechnology, and in particular the academic infrastructure represented by NNIN.[5] In addition, the President's Council of Advisors on Science and Technology (PCAST) 2014 Report to the President and Congress on the Fifth Assessment of the NNI recommends strong support for nanoscale infrastructure networks, such as NNIN, to ensure the effective training of a new generation of transdisciplinary scientists and engineers.[6] NSF sought input from the science and engineering community on a possible future nanotechnology infrastructure support program through a Dear Colleague Letter (NSF 14-068).[7] A workshop[8] attended by recognized national experts was then conducted to develop a vision of how such a future program could be structured and to identify the key needs for the user communities over the coming decade. With this background and community input, NSF has created the NNCI program.

- The initial NNCI award commitments will be for five years and may be renewed once for an additional five years, subject to external merit review. Limited new competitions may be held, based on availability of funds, to address critical needs in nanotechnology or to replace non-performing sites or the CO.

[5] http://nano.gov/sites/default/files/pub_resource/2014_nni_strategic_plan.pdf
[6] www.whitehouse.gov/sites/default/files/microsites/ostp/PCAST/pcast_fifth_nni_review_oct2014_final.pdf
[7] www.nsf.gov/pubs/2014/nsf14068/nsf14068.jsp?org=ENG
[8] www.src.org/newsroom/src-in-the-news/2014/656/

NATIONAL SOLAR OBSERVATORY

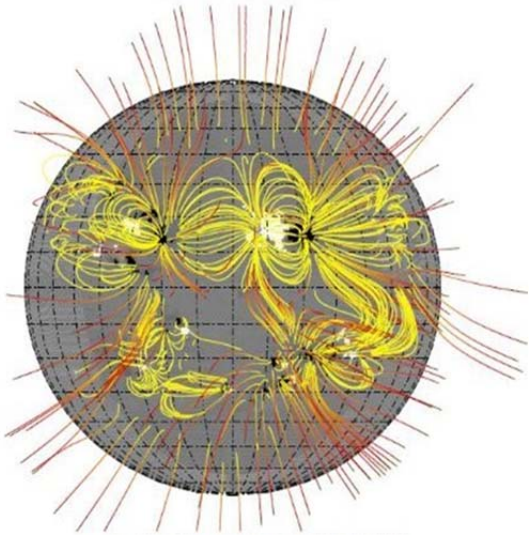
$18,500,000
+$5,500,000 / 42.3%

National Solar Observatory
(Dollars in Millions)

FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Percent
$8.00	$13.00	$18.50	$5.50	42.3%

The FY 2016 Budget Request for the National Solar Observatory (NSO) is $18.50 million. This is a $5.50 million (42.3 percent) increase above the FY 2015 Estimate and includes a one-time request to refurbish NSO infrastructure for space weather prediction. This increase also marks the continuation of a five-year funding ramp that will bring the NSO budget to a level commensurate with requirements to operate the Daniel K. Inouye Solar Telescope (DKIST). This profile will fund the development of the DKIST science operations and data center concepts in preparation for full DKIST operations expected to begin in 2019.

NSO currently operates facilities in New Mexico and Arizona as well as a coordinated worldwide network of six telescopes specifically designed to study solar oscillations. NSO also provides leadership to the solar community through construction of DKIST. (See the Major Research Equipment and Facilities Construction (MREFC) chapter for more information.) NSO makes available to qualified scientists the world's largest collection of optical and infrared solar telescopes and auxiliary instrumentation for observation of the solar photosphere, chromosphere, and corona. NSO also provides routine and detailed, synoptic solar data used by individual researchers and other government agencies through the NSO Digital Library. NSO data are also made available to the user community via the Virtual Solar Observatory.



The solar magnetic field as derived from magnetograms produced by NSO's SOLIS Vector Spectromagnetograph (VSM) Instrument. *Credit: Tadesse et al. 2013, Astronomy & Astrophysics, 550, A14.*

NSO telescopes are open to all astronomers regardless of institutional affiliation on the basis of peer-reviewed observing proposals. In FY 2014, 65 unique observing programs from 21 U.S. and 14 foreign institutions were carried out using NSO facilities. Students were involved in 18 percent of these programs, which included 11 Ph.D. thesis projects. Over 32 terabytes of NSO synoptic data were downloaded from the NSO Digital Library, with approximately 52 percent of the downloads coming from U.S. science institutions (.gov, .edu, and .mil), two percent from other U.S. sources (.com, .net, etc.), and the remaining 46 percent of the downloads coming from international sources. Approximately 137 staff members were employed at NSO in FY 2014, including 50 FTEs employed on the DKIST construction project funded via the MREFC account as mentioned above.

In 2010, the National Research Council (NRC) conducted its sixth decadal survey in astronomy and

astrophysics. In their report, *New Worlds, New Horizons in Astronomy and Astrophysics,*[9] the NRC committee recommended that "NSF-Astronomy should complete its next senior review before the mid-decade independent review that is recommended in this report, so as to determine which, if any, facilities NSF-AST should cease to support in order to release funds for (1) the construction and ongoing operation of new telescopes and instruments and (2) the science analysis needed to capitalize on the results from existing and future facilities." In response to this recommendation, the Division of Astronomical Sciences (AST) conducted a community-based review of its portfolio. The resulting Portfolio Review Committee (PRC) report, *Advancing Astronomy in the Coming Decade: Opportunities and Challenges,*[10] was released in August 2012 and included recommendations about all of the major AST telescope facilities.

Prior to receiving the PRC report, NSF had instructed NSO to begin divestment of the facilities on Kitt Peak including the McMath-Pierce solar telescope and the Vacuum Tower (no longer in use), thereby accelerating the already-planned divestment by a few years. The PRC endorsed this decision. The PRC recommended continued operation of the Dunn Solar Telescope (DST) through 2017 and a 50 percent reduction in funding of the NSO synoptic program. At present, the plan is for the McMath-Pierce telescope to be divested to a small university-based consortium, with short-term transition funding provided by AST as part of the NSO request. By the end of 2017, it is expected that the university-based consortium will have secured the necessary funding for continued operations of the McMath-Pierce at a minimum level. Active partnership discussions are also under way for continued operations of the DST at the NSO's Sacramento Peak facility. In FY 2014, the NSF contracted with a general engineering firm to produce feasibility studies that will provide baseline structural, historical, and environmental surveys of the McMath-Pierce telescope and the various NSO facilities on Sacramento Peak. The purpose of these studies is twofold. First, the study will serve to inform the NSF and potential partners of the current state of the facility. Second, the study will explore various divestment options and provide an assessment of the potential costs involved. After viable options are identified, the NSF will embark on formal reviews (in FY 2015 and FY 2016) to evaluate the impacts of these alternatives, including partnership opportunities that could involve further environmental assessments.

Total Obligations for NSO
(Dollars in Millions)

				ESTIMATES[1,2]				
	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021
NSO Base Operations	$7.78	$7.75	$6.75	$5.74	$4.74	$3.70	$3.82	$3.93
NSO Education & Public Outreach	0.22	0.25	0.25	0.26	0.27	0.30	0.31	0.32
DKIST Operations[2]	-	5.00	9.00	11.50	14.50	17.00	17.50	18.04
GONG Refurbishment	-	-	2.50	-	-	-	-	-
Total, NSO	**$8.00**	**$13.00**	**$18.50**	**$17.50**	**$19.50**	**$21.00**	**$21.63**	**$22.28**

Totals may not add due to rounding.

[1] Outyear funding estimates are for planning purposes only. The current cooperative agreements ends on March 31, 2015.

[2] Total FY 2016 Research and Related Activities account funding for DKIST consists of $9.0 million through NSO, as shown above, and $2.0 million per year for FY 2011 through FY 2020 for cultural mitigation activities as agreed to during the compliance process that is not funded though NSO. See the MREFC chapter for more information on DKIST.

Partnerships and Other Funding Sources: The managing organization for NSO is the Association of Universities for Research in Astronomy (AURA), Inc., which comprises 39 U.S. member institutions and seven international affiliate members. NSO partners include the U.S. Air Force Research Laboratory

[9] www.nap.edu/catalog.php?record_id=12951
[10] www.nsf.gov/mps/ast/ast_portfolio_review.jsp

(AFRL), U.S. Air Force Weather Agency (AFWA), NASA, and industrial entities. The Air Force is the most significant source of external funding to the NSO, providing $1.20 million in operational support for FY 2014. Approximately $400,000 is provided by AFRL in exchange for NSO support for AFRL staff at the Sacramento Peak facility. The remaining $800,000 is provided by AFWA in support of Global Oscillations Network Group (GONG) operations that are used for operational space weather prediction. Other funding entities include universities and institutes, which collaborate with NSO on solar instrumentation development and on the design and development of DKIST. New telescopes, instrumentation, and sensor techniques are developed through industry sub-awardees in aerospace, optical fabrication, and information technology.

NSO Base Operations, $6.75 million: NSO Base Operations includes operations at Sacramento Peak Observatory in Sunspot, New Mexico, facilities based on Kitt Peak, Arizona, and the world-wide NSO Integrated Synoptic Program consisting of the GONG array and the SOLIS (Synoptic Optical Long-term Investigations of the Sun) telescope. In addition, NSO Base Operations funds the NSO Directorate, which is currently in the process of relocating from Tucson, AZ to a new location on the campus of the University of Colorado, Boulder. Boulder, CO has become a national center of solar and space physics. The NSO relocation will place the NSO headquarters squarely in the center of the solar community. The funding profile for NSO Base Operations is ramping down in anticipation of the divestment of redundant facilities by the end of 2017. By the end of this ramp, NSO Base Operations will fund the NSO Directorate activities as well as the NSO synoptic program operations at a steady level of approximately $4.0 million ($2.0 million each) per year.

DKIST Operations, $9.0 million: The request for DKIST Operations represents the second year of a five-year funding ramp that will bring the NSO budget to a level commensurate with requirements to operate DKIST. This profile will fund the development of the DKIST science operations and data center concepts in preparation for full DKIST operations expected to begin in 2019. DKIST construction is not funded here, but instead through the MREFC account. In this FY 2016 request, DKIST takes over the majority share of the NSO Operations budget.

GONG Refurbishment, $2.50 million: There is increasing national and international awareness of the impacts of space weather on critical infrastructure and society in general. As part of this increased awareness, the importance of operational space weather forecasting is becoming apparent to U.S. policy makers. Space weather forecasting requires both accurate models of the heliospheric environment and precise observational data inputs to those models. The NSO's GONG program provides operational data products on a routine basis that are used as inputs to predictive space weather models from federal agencies such as AFWA and the NOAA Space Weather Prediction Center (SWPC). A one-time refurbishment of the GONG infrastructure in FY 2016 will provide a reliable, operations-ready, array of solar stations allowing for nearly continuous data coverage.

Education and Public Outreach, $250,000: NSO supports U.S. education goals by promoting public understanding and support of science and by providing education and training at all levels. NSO introduces undergraduate students to scientific research by providing stimulating environments for basic astronomical research and related technologies through NSF's separately funded Research Experiences for Undergraduates (REU) program. NSO has diverse education programs, including teacher training and curriculum development, visitor centers, and a web-based information portal at www.nso.edu.

Management and Oversight

- NSF Structure: An NSF program officer in AST provides continuing oversight, including consultation with an annual NSF program review panel. The program officer makes use of detailed annual program plans, annual long-range plans, quarterly technical and financial reports, and annual reports submitted by NSO as well as attending AURA Solar Observatory Council meetings. The

latter committee is formed from the national solar physics community and provides a window into community priorities and concerns. The AST program officer works closely with other offices at NSF, particularly the Division of Acquisition and Cooperative Support, the Office of General Counsel, and the Large Facilities Office in the Office of Budget, Finance, and Award Management.

- External Structure: AURA is the managing organization for NSO. The NSO Director reports to the president of AURA, who is the principal investigator on the current NSF cooperative agreement. AURA receives management advice from its Solar Observatory Council, composed of members of its scientific and management communities. NSO employs visiting and users committees for the purposes of self-evaluation and prioritization. The visiting committee, composed of nationally prominent individuals in science, management, and broadening participation, reviews for AURA all aspects of the management and operations of NSO. The users committee, composed of scientists with considerable experience with the observatory, reviews for the NSO Director all aspects of NSO that affect user experiences at the observatory.
- Reviews: In addition to reviews held mid-way through all cooperative agreements, NSF conducts periodic and ad hoc reviews, as needed, by external committees. An extensive NSO review in FY 2008 led to the award of a new cooperative agreement in early FY 2010. A Business Systems Review was held in Spring 2013. A re-baseline review for the DKIST project, described in the DKIST narrative in the MREFC chapter, was held in October 2012. An extensive review of NSO was conducted in January 2014 as part of the renewal of the cooperative agreement.

Renewal/Recompetition/Termination

The National Science Board (NSB) authorized a cooperative agreement with AURA for management and operation of NSO for October 1, 2009 through March 31, 2014. Since NSO is the home for the DKIST construction project, and DKIST is not expected to begin operation until 2019, it was determined that competition of the NSO cooperative agreement should take place after DKIST has achieved full operations, expected in FY 2019. Thus, the current cooperative agreement was first extended through December 31, 2014, and a proposal for the longer-term renewal of the agreement was requested from AURA. This proposal was received by NSF in October 2013, underwent merit review in January 2014, and was approved by the NSB on August 14, 2014. The current cooperative agreement has been extended to March 31, 2015 as negotiations between NSF and the managing organization for the renewed cooperative agreement are ongoing.

NATIONAL SUPERCONDUCTING CYCLOTRON LABORATORY $22,500,000
$0 / 0.0%

National Superconducting Cyclotron Laboratory

(Dollars in Millions)

FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Percent
$22.50	$22.50	$22.50	-	-

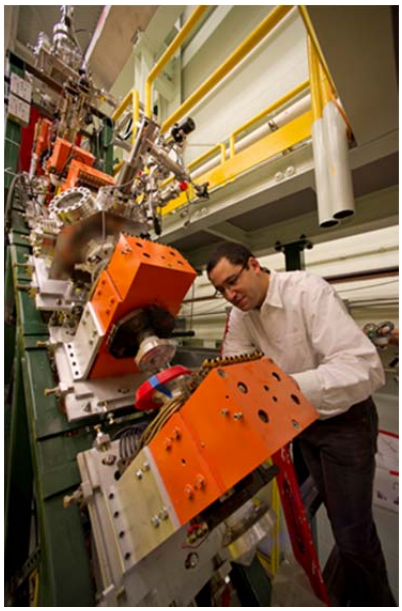
The National Superconducting Cyclotron Laboratory (NSCL) at Michigan State University (MSU) is a university-based national user facility. With two linked superconducting cyclotrons, K500 and K1200, it is the leading rare isotope research facility in the U.S. and is among the world leaders in heavy ion nuclear physics and nuclear physics with radioactive beams. Funding for NSCL also supports the MSU faculty and staff research program.

NSCL scientists employ a range of tools for conducting advanced research in fundamental nuclear science, nuclear astrophysics, and accelerator physics. Applications of research conducted at NSCL benefit society in numerous areas, including new tools for radiation treatments of cancer patients, the assessment of health risks to astronauts, and homeland security. The K500 was the first cyclotron to use superconducting magnets, and the K1200 is the highest-energy continuous beam accelerator in the world. Through the Coupled Cyclotron Facility (CCF), heavy ions are accelerated by the K500 and then injected into the K1200, enabling the production of rare unstable isotopes at much higher intensities. The laboratory has completed construction and commissioning of an MSU-funded reaccelerator facility (ReA3) that will enable experiments at very low energies – a domain of particular interest to nuclear astrophysics. This is the only facility in the world to provide radioactive beams in this energy regime.

Scientists at NSCL work at the forefront of rare isotope research. They make and study atomic nuclei that cannot be found on Earth and perform experimental research using beams of unstable isotopes to extend our knowledge of new types of nuclei, many of which are important to an understanding of stellar processes. Research activities include a broad program in nuclear astrophysics studies, the studies of nuclei far from stability using radioactive ion beams, and studies of the nuclear equation of state. In addition, research is carried out in accelerator physics.

NSCL supports and enhances doctorate graduate education and post-doctoral research experiences. About 10 percent of all doctorates granted in nuclear physics in the U.S. are based on research at NSCL. The lab also provides research experiences for undergraduate students, K-12 students, and K-12 teachers.

The coupled cyclotron facility supports a broad experimental program. The mix of experiments is determined by beam use proposals. An external program advisory committee selects the best proposals at a typical success rate of about 50 percent, with constraints on beam availability. The science output of NSCL is driven by these experiments, with most running one to three days.



Research Physicist Fernando Montes inspects a beamline at the reaccelerated beam facility (ReA3) at NSCL. *Credit: NSCL.*

Total Obligations for NSCL

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	ESTIMATES[1] FY 2017	FY 2018	FY 2019	FY 2020	FY 2021
Operations & Maintenance	$22.50	$22.50	$22.50	$22.50	$22.50	$22.50	$20.00	$15.00

[1] Outyear funding estimates are for planning purposes only. The current cooperative agreement ends in FY 2016.

Management and Oversight

- NSF Structure: MSU operates NSCL under a cooperative agreement with NSF. NSF oversight is provided through annual site visits by the cognizant program officer of the NSF Directorate for Mathematical and Physical Sciences, Division of Physics (MPS/PHY) and other staff, accompanied by external experts.
- External Structure: NSCL is managed by a director and three associate directors (for experimental research, education, and operations) as well as an associate laboratory director for users. The director has the authority to appoint associate directors and designate responsibilities, notifying NSF of changes. NSCL's research program is guided by a program advisory committee of external experts as well as an in-house expert, and includes the chairperson of the full NSCL user group. The procedure for users includes writing and submitting proposals to the NSCL director and oral presentations. Opportunities for proposal submission occur every six to nine months so that the beam hour backlog is no longer than one year. Optimally the laboratory can provide about 5000 beam hours to the scientific community each year, with actual output depending upon facility reliability factors and available funds.
- Reviews:
  - A 5-year review in FY 2011 covered results and achievements related to intellectual merit and broader impacts for the past five years (FY 2007 – FY 2011) and future funding for the next five years (FY 2012 – FY 2016).
  - Latest Review: An annual review of the science, operations, and future funding was in June 2014.
  - Next Review: An annual review is tentatively planned for June 2015.

Renewal/Recompetition/Termination

Over the next several years, NSCL will transition to the new Facility for Rare Isotope Beams (FRIB), which will be built by the Department of Energy (DOE) on the site of the present NSCL and will make use of much of the NSCL beamlines and general infrastructure. MSU will be the performing institution under a cooperative agreement with DOE for the future FRIB. To facilitate interagency planning and allow for a smooth transition from the NSF-funded NSCL to the DOE-funded FRIB, a Joint Oversight Group (JOG) of DOE and NSF personnel has been established. NSF anticipates eventually phasing out funding for operations and maintenance for the NSCL facility, as indicated in the table above for FY 2016 through FY 2021. DOE and NSF will coordinate transfer of facility stewardship as it transitions from NSCL to FRIB. NSF will continue to support individual investigators carrying out research at the new FRIB.

NATURAL HAZARDS ENGINEERING RESEARCH INFRASTRUCTURE

$12,500,000
+$500,000 / 4.2%

Natural Hazards Engineering Research Infrastructure
(Dollars in Millions)

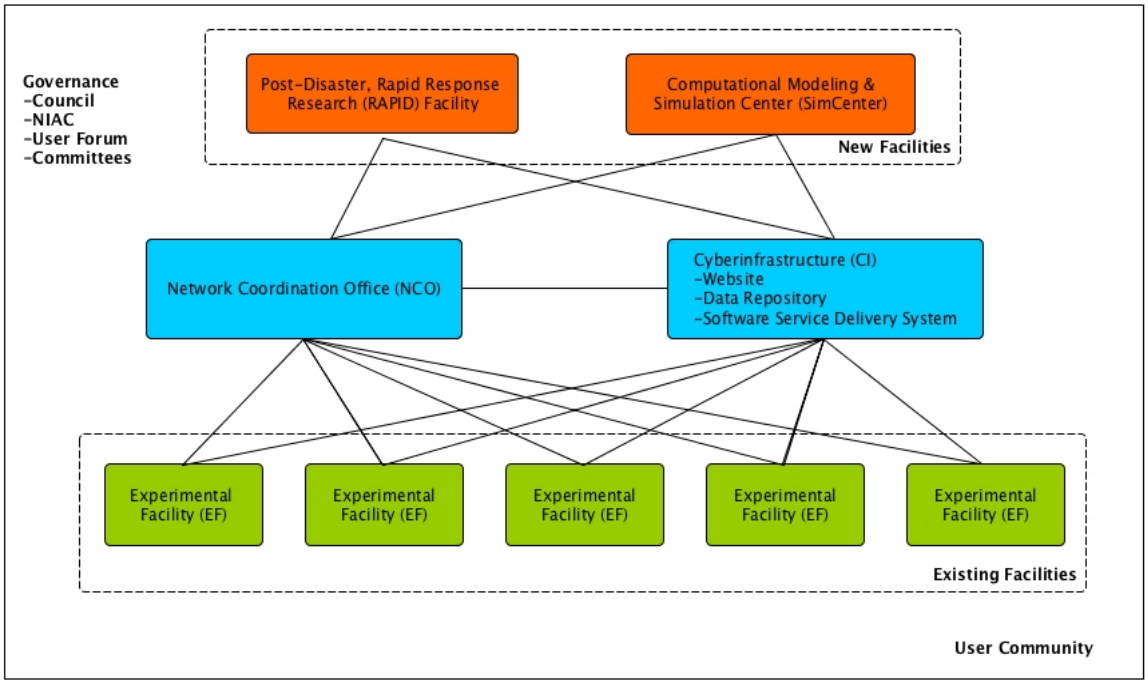
FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Percent
-	$12.00	$12.50	$0.50	4.2%

The Natural Hazards Engineering Research Infrastructure (NHERI) is the next generation of National Science Foundation (NSF) support for multi-user, natural hazards engineering research facility, replacing the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES). NEES was established by NSF as a distributed, multi-user, national research infrastructure for earthquake engineering research through support of a facility construction phase during 2000-2004, followed by an operations phase to support research, innovation, and education activities from October 2004 through September 2014. NEES was supported by NSF during FY 2010-FY 2014 through a cooperative agreement with Purdue University. The NEES infrastructure included 14 earthquake engineering experimental facilities and an integrative cyberinfrastructure. During FY 2015, NSF's cooperative agreement with Purdue University has been extended to continue support for cyberinfrastructure operations during the NSF open competition to establish NHERI via program solicitation NSF 14-605.

During FY 2015 to FY 2019, NHERI will be operated as a distributed, multi-user, national research facility aiming to provide the natural hazards engineering research community with access to research infrastructure (earthquake and wind engineering experimental facilities, cyberinfrastructure, computational modeling and simulation tools, and research data), coupled with education and community outreach activities. NHERI will enable new discovery and knowledge through enhanced capacity to test and derive more comprehensive, complete, and accurate models of how constructed civil infrastructure responds to earthquake and wind loading. This will enable the design of new methodologies, modeling techniques, and technologies for earthquake, windstorm, and multi-hazard mitigation. NHERI will also continue to contribute to the National Earthquake Hazards Reduction Program and the National Windstorm Impact Reduction Program.

NHERI will be established by NSF through up to ten individual cooperative agreements and will consist of the following four components, as shown in Figure 1:

- Network Coordination Office (NCO);
- Cyber-Infrastructure (CI) Operations;
- Computational Modeling and Simulation Center (SimCenter); and
- Up to seven Experimental Facilities (EF), including a new post-disaster, rapid response research (RAPID) facility.



Notional Concept for NHERI (from program solicitation NSF 14-605).

The NCO awardee will serve as the national and international scientific leader, community focal point, and network-wide coordinator for governance and community-building activities. Key activities will include convening the governance groups, working with the Council of Awardees to develop consensus-based policies and procedures for NHERI and the annual Council work plan, implementing the facility scheduling protocol to provide users access to the EFs, leading development of community science plans, running NHERI-wide education and community outreach programs, and building strategic partnerships.
The CI awardee will serve as the integrator for enabling NHERI to be a virtual organization for the natural hazards engineering community, by providing an array of information, resources, and services, including the definitive NHERI website, data repository, software service delivery platform with computational modeling, simulation, and educational tools, collaboration tools, access to computing resources, and user training and support. The CI awardee will establish and implement a NHERI-wide cybersecurity plan with all NHERI awardees.

The SimCenter awardee will develop and deliver to the CI awardee for integration onto the CI awardee's software service delivery platform, a portfolio of computational modeling and simulation software and educational modules that reflects a balance of community-prioritized, new capabilities for earthquake, wind, and multi-hazard engineering research and education.

EF awardees will provide well-maintained and fully functioning facilities, services, and staffing to enable earthquake engineering, wind engineering, or post-disaster, rapid response research requiring experimental work and data collection. Experimental data generated by EF resources and its users will be archived and maintained in the publicly accessible NHERI data repository. The awardees and the natural hazards engineering community will work together, through governance and awardee activities, to establish a shared vision for NHERI, set natural hazards engineering research and education agendas and priorities, and make NHERI a value-added and productive research infrastructure.

Along with direct operations and maintenance support for NHERI awardees, NSF will provide separate support for research to be conducted at the NEHRI experimental facilities through ongoing research and

education programs. The support for such activities primarily will be provided through the Engineering for Natural Hazards (ENH) research program in the Civil, Mechanical and Manufacturing Innovation (CMMI) division in the Directorate for Engineering (ENG). The ENH program will support basic research in multi-hazard engineering involving experimental and computational simulations at the NHERI facilities, addressing important challenges in multi-hazard mitigation for constructed civil infrastructure. With the aim of integrating research and education, NHERI will engage students through on-site use of experimental facilities, telepresence technology, experimental and analytical data, and computational resources. Coordinated by the NCO awardee, NHERI awardees will also run an annual Research Experiences for Undergraduates (REU) program and a Summer Institute.

Total Obligations for NHERI

(Dollars in Millions)

	FY 2014	FY 2015	FY 2016	ESTIMATES[1]				
	Actual	Estimate	Request	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021
Operations & Maintenance	-	$12.00	$12.50	$12.50	$12.00	$12.00	$12.00	$12.00

[1] Outyear funding estimates are for planning purposes only. FY 2015 is the first year of funding for the program.

Management and Oversight

- **NSF structure**: The NSF program manager for NHERI is located within ENG/CMMI . The Deputy Director of the Large Facilities Office in the Office of Budget, Finance and Award Management will provide advice and assistance.

- **Awardee structure**: Each NHERI awardee will be led by a principal investigator (PI), who will be responsible for the overall award operations. The NCO awardee will coordinate NHERI and be responsible for convening NHERI governance. Governance will be comprised of the following groups: (a) a Council, which consists of the PI of each NHERI award, to provide collective and coordinated leadership for NHERI as a national facility, (b) Network Independent Advisory Committee, with diverse representation from the broad scientific and engineering communities served by NHERI, to provide independent external guidance and advice to the Council, (c) User Forum, consisting of representatives from the broad scientific and engineering communities served by NHERI, and (d) Council-identified committees, comprised of internal awardee staff and/or users, to advise the Council on community priorities and needs for NHERI.

- **NSF Oversight and Reviews:** NSF will provide oversight to NHERI awardees through cooperative agreements. Individual and joint awardee operations and activities will be reviewed through quarterly and annual project reports submitted by awardees and site visit reviews conducted by NSF. Site visit reviews will include the following:
  - Site visit merit reviews
    - Annually for NCO, CI, and SimCenter awardees;
    - For EF awardees: Up to four facilities will receive site visits each year.
  - NSF Business Systems Review, for each awardee, with the review to be conducted within the first two years of the award.

Renewal/Recompetition/Termination

- In FY 2010, NSF supported two studies to assess the need for earthquake engineering experimental and cyberinfrastructure facilities beyond 2014, as described in the Dear Colleague Letter NSF 10-071.[11] One study, a workshop held by the National Research Council on the Grand Challenges in

[11] http://nsf.gov/pubs/2010/nsf10071/nsf10071.jsp

Earthquake Engineering Research, was completed in FY 2011 and the second study was completed in FY 2012. These studies provided input to NSF for the determination of support for future earthquake engineering research infrastructure beyond FY 2014. The plan to support a smaller "second generation" NEES (NEES2) during FY 2015-FY 2019 was presented to the National Science Board at their July 2012 meeting and described in the Dear Colleague Letter NSF 12-107.[12] The plan would result in a lower annual operations budget, reflected in the $8.0 million reduction from FY 2014 in the FY 2015 Budget Request, from $20.0 million to $12.0 million, and allow additional investments to be made in earthquake engineering research.

- In February 2013, NSF released solicitation NSF 13-537 in an effort to compete and operate NEES2 for FY 2015-FY 2019. Based on the merit review of proposals submitted under NSF 13-537, NSF made no award. In 2012, National Institute of Standards and Technology and NSF jointly supported a workshop that led to a roadmap report for measurement science research and development for windstorm and coastal inundation impact reduction, which was published in January 2014.[13]
- Based on the above studies and report, NSF established the plan for NHERI in FY 2014. NHERI operations awards will be supported for a five-year period. During this period, the NCO awardee will be responsible, working with the natural hazards engineering research and education community, to develop by September 30, 2017, a decadal science plan for natural hazards engineering research, education, and research infrastructure for 2020 – 2029. NSF will use this decadal science plan as input for natural hazards engineering research infrastructure support beyond 2019.

[12] www.nsf.gov/pubs/2012/nsf12107/nsf12107.jsp
[13] www.nist.gov/customcf/get_pdf.cfm?pub_id=915541

OCEAN OBSERVATORIES INITIATIVE

$55,000,000
$0 / 0.0%

Ocean Observatories Initiative

(Dollars in Millions)

FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Percent
$49.30	$55.00	$55.00	-	-

The Ocean Observatories Initiative (OOI) began in FY 2009 as a Major Research Equipment and Facilities Construction (MREFC) Project. In FY 2015, OOI transitioned from the MREFC construction effort to the long term OOI Program Operations & Maintenance phase.

OOI is a networked ocean-focused research observatory with arrays of instrumented buoys, profilers, gliders and autonomous vehicles within different open ocean and coastal regions, as well as a cabled array of instrumented platforms and profilers on or above the seafloor over the Juan de Fuca tectonic plate. This networked system of instruments, platforms and arrays will provide the ocean scientists, educators and the public the means to collect sustained, time-series data sets that will enable researchers to examine complex, interlinked physical, chemical, biological, and geological processes operating throughout the coastal regions and open ocean. The OOI infrastructure will make interdisciplinary measurements to investigate a spectrum of phenomena and processes including episodic, short-lived events (meteorological, tectonic, volcanic, geological, geophysical, and ecological), and more subtle, long-term changes and emergent phenomena in ocean systems (circulation patterns, climate change, ocean acidity, geophysical events and ecosystem trends).

The OOI facility will provide the public, educators, students and researchers with: (1) OOI long-term time series data sets; (2) an in-situ ocean laboratory capability to allow OOI users to develop and apply new technologies by connecting their instruments or concepts to the OOI network via new proposals; and (3) OOI tools that will support graduate and undergraduate classroom applications of the OOI, as well as public outreach through informal education.

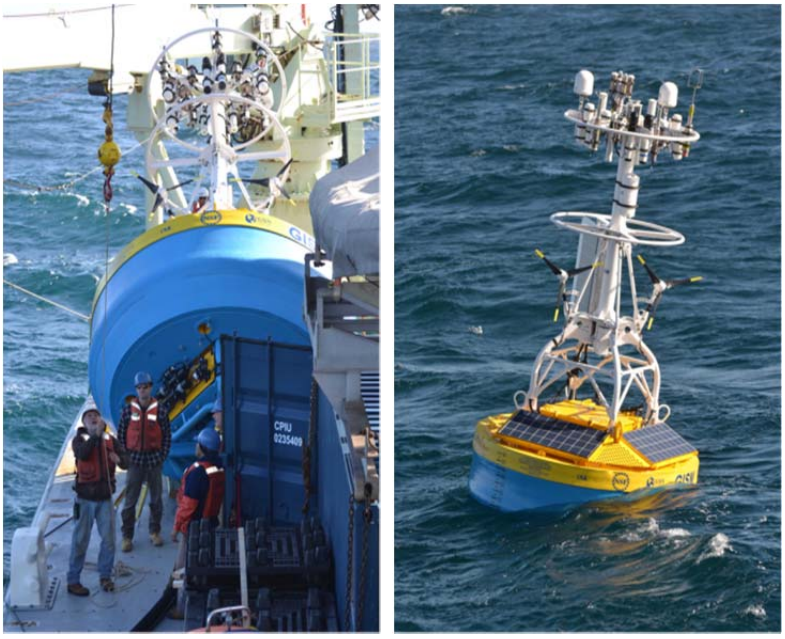
The overarching scientific themes of the OOI span six multi-disciplinary domains, and each theme incorporates a multitude of research questions.

- *Ocean-Atmosphere Exchange.* Quantifying the air-sea exchange of energy and mass, especially during high winds, is critical to providing estimates of energy and gas exchange between the surface and deep ocean, and improving the predictive capability of storm forecasting and climate-change models.
- *Climate Variability, Ocean Circulation, and Ecosystems.* As both a reservoir and distributor of heat and carbon dioxide, the ocean modifies climate, and is also affected by it. Understanding how climate variability will affect ocean circulation, weather patterns, the ocean's biochemical environment, and marine ecosystems is a compelling driver for multidisciplinary observations.
- *Turbulent Mixing and Biophysical Interactions.* Mixing occurs over a broad range of scales and plays a major role in transferring energy, materials, and organisms throughout the global ocean. Mixing has a profound influence on primary productivity, plankton community structure, biogeochemical processes (e.g., carbon sequestration) in the surface and the deep ocean, and the transport of material to the deep ocean.
- *Coastal Ocean Dynamics and Ecosystems.* Understanding the spatial and temporal complexity of the coastal ocean is a long-standing challenge. Quantifying the interactions between atmospheric and terrestrial forcing, and coupled physical, chemical, and biological processes, is critical to elucidating

the role of coastal margins in the global carbon cycle, and developing strategies for managing coastal resources in a changing climate.

- *Fluid-Rock Interactions and the Subseafloor Biosphere.* The oceanic crust contains the largest aquifer on Earth. Thermal circulation and reactivity of seawater-derived fluids modifies the mineralogy of oceanic crust and sediments, leads to the formation of hydrothermal vents that support unique micro- and macro-biological communities, and concentrates methane to form massive methane gas and methane hydrate reservoirs. The role that transient events (e.g., earthquakes, volcanic eruptions, and slope failures) play in these fluid-rock interactions and in the dynamics of benthic and sub-seafloor microbial communities remain largely unknown.
- *Plate-Scale, Ocean Geodynamics.* Lithospheric movements and interactions at plate boundaries at or beneath the seafloor are responsible for short-term events such as earthquakes, tsunamis, and volcanic eruptions. These tectonically active regions are also host to the densest hydrothermal and biological activity in the ocean basins. The degree to which active plate boundaries influence the ocean from a physical, chemical, and biological perspective are largely unexplored.

All data/metadata will be freely available to the public via the Internet. All OOI data including science, engineering and derived data products will flow through the OOI cyberinfrastructure. The OOI website will provide all raw data, metadata, and data processed via conventional algorithms through a data subscription service or direct retrieval from OOI storage or national data archives. The OOI website will provide science educators with a suite of tools (middleware) allowing them to enhance their graduate and undergraduate education activities and engage the general public using ocean observation data from the OOI.



OOI Global Surface Mooring Deployed in the Irminger Sea – September 2014 (one of 41 OOI instrumented moorings). *Credit: Allison Heater, Woods Hole*

Current Status

Many OOI assets have been deployed and are transmitting data. However, because of weather requirements final deployments will extend into Spring of 2015. The OOI operations and maintenance (O&M) budget for FY 2016 is $55.0 million. This request includes the parts, labor, equipment, and ship time required to operate and maintain the OOI moorings and instruments. As assets are deployed, they transition to operations and are supported from the Research and Related Activities account. Deployed OOI instruments are typically visited and replaced twice per year. The O&M budget also includes science, engineering, and management staff to deliver scientific data of known quality, as well as the planning and engineering execution required for safe operations of the facility.

Total Obligations for OOI
(Dollars in Millions)

	Prior Years[1]	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	ESTIMATES[2] FY 2017	FY 2018	FY 2019	FY 2020	FY 2021
R&RA Obligations:									
Concept & Development	$74.90	-	-	-	-	-	-	-	-
Operations & Maintenance	36.80	49.30	55.00	55.00	55.00	55.00	55.00	55.00	55.00
Subtotal, R&RA Obligations	$111.70	$49.30	$55.00	$55.00	$55.00	$55.00	$55.00	$55.00	$55.00
MREFC Obligations:									
Implementation	252.99	27.50	-	-					
ARRA	105.93	-	-	-	-	-	-	-	-
Subtotal, MREFC Obligations	$358.92	$27.50	-	-	-	-	-	-	-
TOTAL Obligations	**$470.62**	**$76.80**	**$55.00**	**$55.00**	**$55.00**	**$55.00**	**$55.00**	**$55.00**	**$55.00**

Totals may not add due to rounding.

[1] Concept & Development funding and Implementation funding are cumulative of all prior years; Operations & Maintenance funding reflects FY 2013 Actuals only.

[2] Outyear funding estimates are for planning purposes only.

The Consortium for Ocean Leadership (OL) is the awardee for OOI operations and maintenance. OL has major subawardees on the project team to operate and maintain the marine infrastructure, manage the scientific data and operate the cyberinfrastructure. The University of Washington operates the OOI cabled array. Oregon State University operates the Coastal Endurance Array. Woods Hole Oceanographic Institution operates the Pioneer Coastal Array as well as the four OOI Global sites with their subawardee Scripps Institution of Oceanography (UC San Diego). Rutgers University manages the OOI data as well as the cyberinfrastructure and the education and public outreach. Raytheon Corporation provides project management support, systems engineering, and software services for the OOI cyberinfrastructure.

Management and Oversight

- NSF Structure: The Division of Ocean Sciences (OCE) in the Directorate for Geosciences (GEO) manages OOI operations located within the Integrative Programs section. The oversight will include the review of observatory metrics, data quality management as well as integration of the OOI with any new science or infrastructure proposals.
- External Structure: Based on a request from NSF, the University National Oceanographic Laboratory System (UNOLS) Council established the Ocean Observatory Science Committee (OOSC). The OOSC provides guidance and science user perspectives on the operations and maintenance for OOI and several other NSF-funded ocean observatories. The OOSC will conduct two user workshops for the OOI in FY 2016. The OOI program will have a science oversight committee to provide input and guidance to Ocean Leadership for OOI infrastructure planning and management.
- Reviews: NSF conducted a review of the project's revised cyberinfrastructure architecture and user interface plans in November 2014. In December 2014 the Project Team presented the Concept of Operations document to NSF and the external community Ocean Observatory Science Committee for review. An external review will be conducted in spring 2015 after completion of the Southern Global Array deployments in support of construction closeout planning. During the Operations and Maintenance phase for OOI, annual external panel reviews will be conducted with participation by the OOSC to represent the user community. The review will coincide with annual work planning and decision making for the next fiscal year. This will allow for input on decisions with respect to technology refresh and instrument upgrades or replacements.

Operations Costs

Operations and maintenance in support of scientific research began in FY 2013 with the deployment of the first OOI instruments. The associated costs are and will continue to be supported by the Division of Ocean Sciences (OCE), with temporary support from the Division of Integrative and Collaborative Education and Research (ICER) from FY 2015-FY 2017. These costs are anticipated to total $55.0 million once the observatory is fully operational in FY 2015. Support for research utilizing observatory data will be through existing programs in OCE, however because the data is freely available over the internet researchers around the world will have access to the unique data sets OOI will produce regardless of the source of their support.

Education and Outreach

Rutgers University, in partnership with the University of Maine, leads OOI's Education and Public Engagement activities. With its unique access to the ocean, OOI education activities are intended to allow researchers, students, and the public to explore the ocean's depths in near real time. To enable this vision, a series of educational tools will be developed which will provide easy and broad access to OOI data and data products. In addition, the tools will support incorporation of OOI's research data into educational materials.

Renewal/Recompetition/Termination

The OOI operations and maintenance cooperative agreement award with OL ends in FY 2017. A recompetition for the operations and maintenance of the OOI program will be conducted in FY 2016.

POLAR FACILITIES AND LOGISTICS

$302,900,000
+$5,430,000 / 1.8%

Polar Facilities and Logistics

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Change over FY 2015 Estimate Percent
Polar Facilities	$196.99	$191.31	$195.11	$3.80	2.0%
Polar Logistics	113.02	106.16	107.79	1.63	1.5%
Total, Polar Facilities and Logistics	**$310.01**	**$297.47**	**$302.90**	**$5.43**	**1.8%**

Totals may not add due to rounding.

Polar Facilities

The Division of Polar Programs (PLR) within the Directorate for Geosciences (GEO) provides the infrastructure needed to support U.S. research conducted in Antarctica, including research funded by U.S. mission agencies, for year-round work at three U.S. stations, on two research ships, and at a variety of remote field camps. One example of support to other agencies includes mission-essential satellite communications support at McMurdo Station for the Joint Polar Satellite System (JPSS), and the National Aeronautics and Space Administration's (NASA) Ground Networks for the relay of data. Through a partnership with the National Oceanic and Atmospheric Administration (NOAA), NASA, and the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT), PLR supports relay of real-time satellite-based weather information that informs global forecasting. In addition, PLR enables important climate monitoring activities for NOAA at the Clean Air Facility at South Pole Station, one of only five such sites around the globe. PLR also provides support for: NASA's Long Duration Balloon program that enables research in fields ranging from astrophysics to cosmic radiation to solar astronomy; the U.S. Geological Survey's (USGS) South Pole Remote Earth Science and Seismological Observatory (SPRESSO), the most seismically-quiet station on earth; and access to the Global Navigation Satellite System (GNSS).

All support for these activities is provided by PLR, including transportation, facilities, communications, utilities (water and power), health and safety infrastructure, and environmental stewardship. The U.S. Antarctic Program (USAP) maintains the U.S. presence in Antarctica in accordance with U.S. policy, and supports Antarctic Treaty administration under State Department leadership.

Total Obligations for Polar Facilities

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	ESTIMATES[1] FY 2017	FY 2018	FY 2019	FY 2020	FY 2021
Antarctic Infrastructure and Logistics	$196.99	$191.31	$195.11	$195.11	$195.11	$195.11	$195.11	$195.11
Total, Polar Facilities	**$196.99**	**$191.31**	**$195.11**	**$195.11**	**$195.11**	**$195.11**	**$195.11**	**$195.11**

Totals may not add due to rounding.

[1] Outyear funding estimates are for planning purposes only.

PLR contracts with a prime contractor for science support, operations, the leasing of research vessels, and the maintenance of the Antarctic stations and related infrastructure in New Zealand and Chile. The contractor is selected through a competitive process. Rotary- and fixed-wing aircraft used in support of

research are also provided through separate competitively-awarded contracts. Other agencies and contractors provide technical support in areas of expertise such as engineering, construction, and communications. Following a major refurbishment program, the U.S. Coast Guard's (USCG) *Polar Star* is expected to provide icebreaking services for the McMurdo Station resupply effort through the end of her extended service life (in approximately 2022).

Management and Oversight

- NSF Structure: PLR staff, including subject matter experts in operational and scientific disciplines, have overall responsibility for funding and managing Polar Facilities under the USAP that NSF budgets for and manages on behalf of the Nation. This includes planning all activities and overseeing contractors. PLR's Antarctic Sciences section funds merit-reviewed research proposals for which access to Antarctica is essential to advancing the scientific frontiers and that can only be achieved or are best achieved with research work in Antarctica and the Southern Ocean. Research is conducted in a broad array of geo- and bio- sciences, including earth system science, as well as space and astrophysical sciences. The Antarctic Infrastructure & Logistics section enables research in Antarctica on behalf of the U.S. government through a network of stations, labs, equipment, and logistical resources. The Environment, Health, and Safety section oversees the environmental, health, and safety aspects of research and operations conducted in Polar Regions.

Helicopters provide support to field parties in the McMurdo Dry Valleys in southern Victoria Land and at remote field camps. *Credit: Kristan Hutchison, RPSC*

- External Structure: The Antarctic support contract was competed and awarded to Lockheed Martin Corporation in December 2011. There are many separate subcontractors for supplies and technical services, and other services are procured through separate competitively-bid contracts.
- Reviews: PLR evaluates the performance of the Antarctic support contractor annually via an Award Fee Plan, which involves multiple tiers of review, including a Performance Evaluation Board (PEB) composed of representatives from PLR and the Office of Budget, Finance, and Award Management (BFA). In addition, PLR's performance is reviewed externally by Committees of Visitors and the GEO Advisory Committee. The USAP Blue Ribbon Panel (BRP) released a report on its review of the program in July 2012.[14] The NSF response to the USAP Blue Ribbon Panel report was released in March 2013.[15]

Current Status

- All facilities (stations, research vessels, and field camps) are currently operating normally.
- The USAP BRP report concluded that ushering in a new age of Antarctic science simply by expanding traditional methods of logistical support would be prohibitively costly. Instead, it recommended numerous ways to more efficiently and cost-effectively support research while maintaining high standards of safety and increasing the flexibility to support evolving science foci in the future. Continued progress is planned to implement BRP recommendations, including investment in prioritized lifecycle acquisitions. Priority will also be given to site work that would be needed to support implementation of the Antarctic Infrastructure Modernization for Science (AIMS) program, currently in the early stages of design. While overall project scope is still being refined, the AIMS project is preparing plans for, among other things, possible replacement of the Palmer Station pier for long-term access to unique research and redevelopment of McMurdo Station to be a smaller, more

[14] www.nsf.gov/od/opp/usap_special_review/usap_brp/rpt/index.jsp
[15] www.nsf.gov/od/opp/usap_special_review/usap_brp/rpt/nsf_brp_response.pdf

efficient facility. The latter includes: replacing major logistic facilities concerning the airplane runway and vessel operations; upgrading facilities for fuel containment, utilities distribution and fire protection; and upgrading satellite communications systems to support operations and research. Additional information is included in the PLR narrative in the GEO chapter.

Renewal/Recompetition/Termination

- In FY 2012, Lockheed Martin Corporation was awarded a 13.5-year contract, consisting of a five-year base period and four option periods, exercised on the basis of performance, that total an additional 8.5 years.
- A new contract for helicopter support was awarded to Petroleum Helicopters, Inc., the incumbent, in May 2013. The award term is for one year, with the possibility of four additional one-year options exercised on the basis of performance.
- U.S. policy directs NSF to maintain an active and influential presence in Antarctica, including year-round occupation of South Pole Station and two coastal stations. As the scientific forefronts addressed there evolve over time, so do the research emphases at the three stations and the infrastructure needed to support them.

Polar Logistics

Polar Logistics consists of two activities: the U.S. Antarctic Logistical Support program within the Antarctic Infrastructure and Logistics section, and the Research Support and Logistics program within the Arctic Sciences section.

Total Obligations for Polar Logistics

(Dollars in Millions)

	FY 2014	FY 2015	FY 2016	ESTIMATES[1]				
	Actual	Estimate	Request	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021
U.S. Antarctic Logistical Support	$68.94	$67.52	$67.52	$67.52	$67.52	$67.52	$67.52	$67.52
Arctic Research Support and Logistics	44.08	38.64	40.27	40.27	40.27	40.27	40.27	40.27
Total, Polar Logistics	**$113.02**	**$106.16**	**$107.79**	**$107.79**	**$107.79**	**$107.79**	**$107.79**	**$107.79**

Totals may not add due to rounding.

The U.S. Antarctic Logistical Support program funds support activities provided by the U.S. Department of Defense (DoD). DoD operates as a logistical support provider on a cost-reimbursable basis. Major funding elements of DoD support include: military personnel, LC-130 flight operations, and maintenance support through the 109th Airlift Wing of the New York Air National Guard in Scotia, New York, and Antarctica; transportation and training of military personnel supporting the USAP; support for air traffic control, weather forecasting, and ground electronics maintenance; the charter of Air Mobility Command airlift and Military Sealift Command ships for the re-supply of McMurdo Station; bulk fuel purchased from the Defense Logistics Agency; and reimbursement for use of DoD satellites for communications.

The Research Support and Logistics program in the Arctic Sciences section of PLR responds to science supported by the section. Funding is provided directly to grantees or to key organizations that provide or manage Arctic research support and logistics. A contractor provides research support and logistics services for NSF-sponsored activities in the Arctic. Additional major support components include: access to USCG and other icebreakers, University-National Oceanographic Laboratory (UNOLS) vessels and coastal boats; access to fixed- and rotary-wing airlift support; upgrades at Toolik Field Station, University of Alaska Fairbanks' field station for ecological research on Alaska's North Slope; safety training for

field researchers and funding for field safety experts; global satellite telephones for emergency response and improved logistics coordination; and development of a network of strategically placed U.S. observatories linked to similar efforts in Europe and Canada.

Management and Oversight

- NSF Structure: PLR has overall responsibility for U.S. Antarctic Logistical Support and Arctic Research Support & Logistics.
  - U.S. Antarctic Logistical Support is budgeted for and managed by the Antarctic Infrastructure and Logistics Section, which includes managers with operational expertise responsible for planning and overseeing all USAP support.
  - Arctic Sciences personnel support merit-reviewed research proposals in social, earth systems, and a broad range of natural sciences; its Research Support & Logistics program responds to research by assisting researchers with access to the Arctic and sharing of plans and results with local Arctic communities. The Environment, Health, and Safety section oversees the environmental, health, and safety aspects of research and operations conducted in polar regions.
- External Structure:
  - DoD operates as a logistical support provider on a cost-reimbursable basis. The agencies cooperate under a Memorandum of Agreement that includes guidance for planning and scheduling and sets forth the terms and conditions for reimbursement to DoD by NSF.
  - The Arctic support contract was re-competed and awarded to the incumbent, CH2M Hill, in September 2011. There are many separate subcontractors for supplies and technical services, and other services are procured through separate competitively bid contracts.
- Reviews: PLR evaluates the performance of the Arctic support contractor informally on an ongoing basis and formally each year using feedback from the research community they support, and by conducting site visits that include representatives from PLR and BFA. PLR's performance is externally reviewed by Committees of Visitors and the GEO Advisory Committee.

Current Status

- All facilities (stations, research vessels, and field camps) are currently operating as normal.

Renewal/Recompetition/Termination

- NSF recompeted the Arctic support contract and made an award to the incumbent contractor, CH2M Hill, in September 2011. The contract has an initial term of four years and the possibility of two, two-year extensions exercised on the basis of performance.

SEISMOLOGICAL FACILITIES FOR THE ADVANCEMENT OF GEOSCIENCE AND EARTHSCOPE

$25,100,000
+$750,000 / 3.1%

Seismological Facilities for the Advancement of Geoscience and EarthScope

(Dollars in Millions)

FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Percent
$24.35	$24.35	$25.10	$0.75	3.1%

The Seismological Facilities for the Advancement of Geoscience and EarthScope (SAGE) comprise a distributed, multi-user, national facility for the development, deployment, and operational support of modern digital seismic instrumentation to serve national goals in basic research and education in the Earth sciences, earthquake research, global real-time earthquake monitoring, and nuclear test ban verification. SAGE is managed and operated for NSF by the Incorporated Research Institutions for Seismology (IRIS), a consortium of 122 U.S. universities and non-profit institutions with research and teaching programs in seismology, 22 educational affiliates, two U.S. affiliates, and 125 foreign affiliates. SAGE was formed in late FY 2013 from part of the EarthScope program and the IRIS facility. The FY 2016 Request will allow SAGE to continue providing service to the community consistent with that in previous years.

Total Obligations for SAGE

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	ESTIMATES[1] FY 2017	FY 2018	FY 2019	FY 2020	FY 2021
Operations & Maintenance	$24.35	$24.35	$25.10	$25.10	$25.10	$25.10	$25.10	$25.10

Totals may not add due to rounding.

[1] Outyear funding estimates are for planning purposes only. The current cooperative agreement ends on September 30, 2018.

The Earth's interior remains a major scientific frontier holding the key to understanding the origin of the planet. Recent developments in seismic sensor design, and the acquisition, transmission, and storage of data have resulted in dramatic improvements in the resolving power of seismic imaging of the interior. To serve the research needs of the broad Earth science community, SAGE is organized under three primary service areas and two special emphasis areas:

Instrumentation Services

- The Global Seismographic Network (GSN) consists of over 150 permanently installed broadband digital seismic stations, most of which have real-time data access.
- Portable Seismology (PS) includes a pool of over 5,200 portable seismometers that are made available to the Earth science research community for a wide range of principal investigator-driven experiments largely funded through the NSF merit review process, and incorporates equipment from the former Program for Array Seismic Studies of the Continental Lithosphere (PASSCAL) and EarthScope USArray/Flexible Array (FA) activities.
- Polar Support Services (PSS) supports the development of specialized seismic equipment for use in harsh environments and provides instrumentation, training, and field support for experiments in the polar regions. Additional supplemental funding for these activities is provided through the Division of Polar Programs (PLR).
- The Transportable Array (TA) is a continental-scale seismic observatory designed to provide a foundation for multi-scale integrated studies of continental lithosphere and deep Earth structure. TA incorporates over 400 stations across the lower 48 states, Alaska, and Canada.

- The Magnetotelluric (MT) component exploits the natural variations in Earth's magnetic and electric fields to provide information on the distribution and composition of fluids in Earth's crust and upper mantle, which gives constraints on Earth's structure that are complementary to those resulting from seismology. MT comprises seven backbone stations and 21 transportable instruments used for short-term deployments.
- Instrumentation Services-Coordinated Activities include efforts to develop the next generation of seismic instrumentation for large-scale scientific experiments; global scale geophysical networks; and training courses to distribute best practices to partners worldwide.

Data Services

- SAGE Data Services (DS) manages an archive of over 200 terabytes of seismic, magnetotelluric, and other data from all SAGE components, the EarthScope program, and numerous affiliated networks; operates automated and manual systems to ensure the quality of all data stored in the archive; and provides systems to give the national and international research community timely access to these data.

Education and Public Outreach

- The SAGE Education and Public Outreach (EPO) program enables audiences beyond seismologists to access and use seismological data and research, including student internships, and programs for under-resourced educational institutions.

Special Emphasis Areas

- Community Activities include scientific and technical workshops that bring together the international seismic community and publications designed to communicate SAGE activities and results to the community.
- International Development Seismology (IDS) leverages the core SAGE Service Areas to provide capacity building and training for earthquake hazard mitigation in developing countries, through technical assistance and research collaborations with scientists at U.S. academic institutions.

Besides its role in providing the observational data essential for basic Earth science research, SAGE also provides real-time seismic data to the U.S. Geological Survey (USGS) and the National Oceanic and Atmospheric Administration (NOAA) for global earthquake, volcano, and tsunami monitoring; international seismic monitoring of compliance with the Comprehensive Test Ban Treaty; and bringing seismology to students and the public through the activities of its EPO program.

SAGE is heavily involved in partnership activities, many international in nature. Installation and operation of the GSN has put IRIS in contact with scientists, as well as government and non-governmental organizations, from around the world. Many international GSN stations are designated as the official stations for nuclear test ban monitoring in their host countries. SAGE also provides multi-use resources for other government agencies that have responsibilities for development of a nuclear test ban monitoring capability and for monitoring global seismicity. For these purposes, agencies in partnership with NSF have provided substantial support for accelerated development of the GSN, shared operation and maintenance of the GSN, and accelerated development of the PS instrument pool.

The EarthScope, Geophysics, GeoPRISMS, and Tectonics Programs in the Division of Earth Sciences (EAR); the GeoPRISMS and Marine Geology and Geophysics Programs in the Division of Ocean Sciences (OCE); and the Geology and Geophysics Program and the Glaciology Program in the Antarctic Research Section of the Division of Polar Programs (PLR) provide most of the funds, totaling approximately $15.0 million per year, for NSF-sponsored research making use of SAGE. Funds permit

deployment of portable seismic instruments and use of data managed by Data Services to solve major Earth science problems.

Management and Oversight

- NSF Structure: The Division of Earth Sciences (EAR), through its Instrumentation & Facilities program (IF), provides general oversight of SAGE to help assure effective performance and administration. The program also facilitates coordination of SAGE programs and projects with other NSF-supported facilities, and with other federal agencies, and evaluates and reviews the performance of IRIS in managing and operating SAGE.
- External Structure: SAGE is managed and operated by IRIS, which is incorporated as a non-profit consortium representing 122 U.S. universities and non-profit organizations with research and teaching programs in seismology. Each voting member institution of the Consortium appoints a member representative, and these member representatives elect the nine members of the IRIS Board of Directors. The Board members, who serve three-year terms, vet all internal program decisions associated with SAGE management and operation, through consultation with IRIS staff and SAGE advisory committees (one for each major SAGE component and additional *ad hoc* working groups appointed for special tasks). The Board of Directors appoints a president of IRIS to a renewable two-year term. The president is responsible for IRIS operations, all of which are managed through the IRIS Corporate Office located in Washington, DC.
- Reviews: All major ongoing geoscience facilities routinely undergo mid-award reviews of their management, in addition to peer review of proposals for new or continued support. The formal NSF merit review of the five-year proposal for the SAGE facility took place in 2012 and 2013 and was also the most recent review of IRIS. Although the *ad hoc* reviewers and two independent review panels had a number of specific recommendations at the working level for SAGE, overall the review found that SAGE was a critical facility for U.S. and international Earth sciences. Furthermore, the reviewers found that IRIS is a well-managed and effective organization that has, through its commitment to the collection and open dissemination of the highest quality seismological data, transformed the discipline of seismology.

Renewal/Recompetition/Termination

Funding for the current cooperative agreement for SAGE began in FY 2014 and ends in FY 2018. In FY 2017, in keeping with the phased integration and recompetition plan presented to and concurred with by the National Science Board in December 2009, NSF intends to solicit proposals for a future facility or facilities to support the Earth sciences research and education community currently supported by SAGE and the related Geodetic Facilities for the Advancement of Geoscience and EarthScope (GAGE). NSF is currently considering the precise form of this solicitation, and any possible future facility/facilities are currently being considered within NSF and through discussions with the SAGE and GAGE support communities.

FEDERALLY FUNDED RESEARCH AND DEVELOPMENT CENTERS (FFRDCS)

NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

$99,000,000
+$800,000 / 0.8%

National Center for Atmospheric Research
(Dollars in Millions)

FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Percent
$96.60	$98.20	$99.00	$0.80	0.8%

The National Center for Atmospheric Research (NCAR) is a Federally Funded Research and Development Center (FFRDC) serving a broad research community, including atmospheric and geospace scientists and researchers in complementary areas of the environmental sciences and geosciences. NCAR is managed under a cooperative agreement between NSF and the University Corporation for Atmospheric Research (UCAR), a university-governed and university-serving organization comprising 105 degree-granting academic institutions.

As of December 2014, NCAR supported a total of 782.9 full time equivalents (FTEs), of which 336.2 are funded under the NSF primary award to UCAR.

Number of FTEs Supported at NCAR

FTEs	Primary Award[1]	All Funding
Career Scientists	75.7	104
Scientific Support[2]	224.8	533.7
Other Staff[3]	35.7	145.2
Total	**336.2**	**782.9**

[1] The primary award supports substantial infrastructure that does not include staff costs.

[2] Scientific Support includes Associate Scientists, Project Scientists, Post Docs, Software Engineers, Engineers, System Support and Technicians.

[3] Other Staff includes Administrative positions, Managers, Paid Visitors, Pilots, Mechanics.

NCAR provides facilities, including world-class supercomputing services, research aircraft, a transportable ground-based radar system, atmospheric sounding, and other surface sensing systems, to university, NCAR, and other atmospheric researchers. NCAR operates several facilities dedicated to the study of the Sun and solar phenomena (e.g., the Mauna Loa Solar Observatory), space weather, and the responses of the upper atmosphere to the Sun's output.

Total Obligations for NCAR

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	ESTIMATES[1] FY 2017	FY 2018	FY 2019	FY 2020	FY 2021
Aircraft Support	$9.17	$9.46	$9.47	$9.47	$9.47	$9.47	$9.47	$9.47
Computational Infrastructure	26.07	26.90	26.91	26.91	26.91	26.91	26.91	26.91
Other Facility Support	21.77	21.01	21.02	21.02	21.02	21.02	21.02	21.02
Research & Education Support	39.59	40.83	41.60	41.60	41.60	41.60	41.60	41.60
Total, NCAR	**$96.60**	**$98.20**	**$99.00**	**$99.00**	**$99.00**	**$99.00**	**$99.00**	**$99.00**

Totals may not add due to rounding.

[1] Outyear funding estimates are for planning purposes only.

Partnerships and Other Funding Sources: NCAR leverages NSF support with funding provided by other federal agencies and non-federal sources. In FY 2014, NCAR received approximately $38.50 million in support from other federal agencies, such as the National Oceanic and Atmospheric Administration (NOAA), and the Federal Aviation Administration (FAA), and $13.30 million from non-federal sources.

Major Investments in FY 2016: In FY 2016, investments at NCAR will focus on fundamental research aimed at improving our ability to predict atmospheric, chemical, and space weather hazards, and increasing our understanding of the variability in the Earth's climate system at regional and global scales. In all of these areas, NCAR scientists will work with their university colleagues to further understand the fundamental processes that control the Earth's climate and weather systems. This will include research thrusts in areas such as the role of the chemical composition of the atmosphere and impacts of changes in that composition on the climate system, better understanding of the structure and nature of hurricanes and other severe weather events, and the impacts of the Sun on space weather and weather on Earth.

Aircraft Support: NCAR operates two NSF aircraft: a C-130Q Hercules and a Gulfstream-V (G-V, also known as the High-Performance Instrumented Airborne Platform for Experimental Research, or HIAPER), both of which are highly modified and equipped with specialized instrumentation, to enable the support of research activities designed to provide new insights into atmospheric chemical processes, the dynamics and coupling of the atmosphere's layers, and interactions between the atmosphere and Earth's surface. The two aircraft will support several community-originated projects deemed by peer review to be of exceptional scientific merit.

Computational Infrastructure: NCAR operates a petascale supercomputing facility in Cheyenne, Wyoming (the NCAR-Wyoming Supercomputing Center), that supports high-end community modeling programs in climate, weather, and other Earth Systems processes. These include the Community Earth System Model (CESM) and the Weather Research and Forecasting Models (WRF), which use mathematical formulas to simulate and better understand the chemical and physical processes that drive Earth's climate and weather system. NCAR leads the development of these community models and supports many thousands of users in the U.S. and worldwide. NCAR also maintains extensive data archives, providing access to a vast collection of observational, experimental and modeling data, together with sophisticated analysis and visualization facilities, and training and support for users of all levels.

Other Facility Support: In addition to the C-130 and G-V aircraft, NCAR provides support for a number of other atmospheric observing platforms through its Earth Observing Laboratory (EOL), including a large, deployable, dual-wavelength Doppler radar, upper atmosphere observing capabilities, an advanced coronagraph, and other experimental systems.

Research and Education Support: Total funding for research and education support at NCAR is estimated to be $41.60 million in FY 2016. As an internationally recognized center of excellence, NCAR operates

scientific research programs that include the following areas:

- studies of large-scale atmospheric and ocean dynamics that contribute to an understanding of the past and present climate processes and global climate change;
- global and regional atmospheric chemistry, including atmospheric connections to geochemical and biogeochemical cycles;
- the variable nature of the sun and the physics of the corona and their interaction with the Earth's magnetic field;
- the physics of clouds, thunderstorms, precipitation formation, and their interactions and effects on local and regional weather; and
- examination of human society's impact on and response to global environmental change.

Research collaborations among NCAR staff and university colleagues are integral to its success as an institution, and serve as a focus and meeting point for the broader atmospheric and related sciences community. NCAR also maintains extensive partnerships and collaborations with the private sector through directed research and technology transfer. This work focuses on developing weather and climate information tailored to the specific needs of stakeholders in a variety of sectors, including energy, aviation, and agriculture.

The Mesa Laboratory, designed by architect I.M. Pei, in Boulder, CO. *Credit: NCAR.*

Educational activities include the SOARS (Significant Opportunities in Atmospheric Research and Science) program that integrates research, education, and mentoring to bridge the undergraduate-to-graduate transition and to broaden participation in the atmospheric and related sciences.

In addition, NCAR further supports the scientific community by providing fellowships, internships, workshops, and colloquia for students and visiting scientists, and disseminates knowledge of the geosciences. Professional training courses, innovative and award-winning science education websites,[16] as well as the directed activities of NCAR's education and outreach programs are further examples of how NSF's goal of integrating research and education is attained through NCAR activities.

Management and Oversight

- NSF Structure: NSF's Division of Atmospheric and Geospace Sciences (AGS), along with the Division of Acquisition and Cooperative Support (DACS), provide oversight of NCAR and the cooperative agreement with the University Corporation for Atmospheric Research (UCAR) for NCAR's management. The cooperative agreement encourages interactions between NCAR scientists and AGS staff and ensures close coordination between AGS and NCAR management. The agreement contains requirements for AGS's oversight of the NCAR program and UCAR management activities that affect NCAR. These include a provision that UCAR submit for AGS approval an annual program plan that details how resources will be used. In addition, NCAR summarizes its past year's accomplishments in an annual scientific report. Annual strategic planning between AGS, UCAR, and NCAR ensure that scientific and facility priorities remain consistent with those of NSF.
- External Structure: UCAR works in partnership with NSF and the university community to ensure

[16] www.spark.ucar.edu

effective implementation of the NCAR strategic mission to the benefit of the research community. In addition, other research sponsors, such as NOAA, the National Aeronautics and Space Administration (NASA), the Department of Energy (DOE), the Department of Defense (DOD), the Environmental Protection Agency (EPA), and the FAA support research collaboration wherever it enhances NCAR's NSF-supported research goals or facilities missions.

- Reviews: A Committee of Visitors (COVs) is convened every three years to evaluate AGS oversight of NCAR. The most recent COV was conducted in FY 2012 with the next anticipated in FY 2015. A Business Systems Review was conducted in FY 2011, and the next review will take place in FY 2016. No significant issues were raised in either of the most recent reviews. Based on a thorough review of NCAR's performance as a center and UCAR's management of NCAR, UCAR was awarded a new five-year cooperative agreement to manage NCAR beginning in FY 2014. It is anticipated that the management of NCAR will be re-competed prior to the next award period, which will begin in FY 2019.

Renewal/Recompetition/Termination

- The award to manage NCAR was last re-competed in FY 2007, and the new award began on October 1, 2008. During 2011, AGS conducted a series of six site visits to NCAR with a total of 38 external reviewers to examine NCAR's science programs and management. Each site visit team reported that NCAR continues to serve a critical role in the ongoing success of the atmospheric and related sciences communities and that the Center and staff remain at the forefront of their respective fields.

- Based on the strong endorsement of reviewers and UCAR's conduct during the award period, AGS informed the National Science Board in May 2012 that UCAR would be permitted to submit a proposal to renew the award for a further five years, after which it would be competed again. UCAR's proposal was received in September 2012 and was reviewed by an eight-member panel with expertise in research, management, and business from the academic, public, and private sectors. The panel found that the proposal scored highly in each evaluation category and recommended without reservation that the proposal be funded in full. In May 2013, AGS presented the results of the proposal review to the National Science Board, which subsequently authorized the Acting Director of NSF to renew the award for the five-year period from October 2013 – September 2018. NSF expects that any future award for the management and operation of NCAR will be subject to full and open competition.

NATIONAL OPTICAL ASTRONOMY OBSERVATORY

$21,750,000
-$3,750,000 / -14.7%

National Optical Astronomy Observatory

(Dollars in Millions)

FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Percent
$25.50	$25.50	$21.75	-$3.75	-14.7%

The National Optical Astronomy Observatory (NOAO) was established in 1982 by uniting operations of the Kitt Peak National Observatory (KPNO) in Arizona and the Cerro Tololo Inter-American Observatory (CTIO) in Chile. As a Federally Funded Research and Development Center sponsored by NSF, the primary purpose of NOAO is to serve as the U.S. national center for optical and infrared (OIR) science and system integration on behalf of the astronomical community. NOAO's mission is to enable discovery in ground-based OIR astronomy. In pursuit of this mission, NOAO facilitates access for all qualified professional researchers to state-of-the-art observational capabilities and databases in OIR astronomy, and enables the U.S. research community to pursue a broad range of modern astrophysical challenges from small bodies within the Solar System, to the most distant galaxies in the early Universe, to indirect observations of dark energy and dark matter. NOAO is the gateway for the U.S. astronomical community to the International Gemini Observatory and to other U.S. OIR telescopes that offer public access. NOAO manages national community involvement in the development of potential future infrastructure projects. In partnership with the community and NSF, NOAO works with colleges and universities to train the next generation of scientists and engineers, and promotes accomplishments to strengthen education and public awareness of the astronomical sciences.

NOAO telescopes are open to all astronomers regardless of institutional affiliation on the basis of peer-reviewed observing proposals. They serve nearly 1,200 U.S. and foreign scientists annually. Doctoral dissertation students and non-thesis graduate students from U.S. institutions use NOAO telescopes for research projects. In FY 2014 NOAO employed 350 personnel in Arizona and Chile, including 45 support scientists and 10 postdoctoral fellows.

In 2010, the National Research Council (NRC) conducted its sixth decadal survey in astronomy and astrophysics. In their report, *New Worlds, New Horizons in Astronomy and Astrophysics*, the NRC committee recommended that "NSF-Astronomy should complete its next senior review before the mid-decade independent review that is recommended in this report, so as to determine which, if any, facilities NSF-AST should cease to support in order to release funds for (1) the construction and ongoing operation of new telescopes and instruments and (2) the science analysis needed to capitalize on the results from existing and future facilities." In response to this recommendation, the Division of Astronomical Sciences (AST) conducted a community-based review of its portfolio. The resulting Portfolio Review Committee (PRC) report, *Advancing Astronomy in the Coming Decade: Opportunities and Challenges*[17] was released in August 2012 and included recommendations about all of the major AST telescope facilities.

The recommendations from the PRC report included divesting NSF support from three nighttime OIR telescopes located on Kitt Peak: the 4-meter Mayall telescope, the 2.1-meter telescope, and the 3.5-meter WIYN (Wisconsin-Indiana-Yale-NOAO) telescope. The first two of these telescopes are NOAO

[17]www.nsf.gov/mps/ast/ast_portfolio_review.jsp

facilities that have been fully available (except for closure due to weather or maintenance) for astronomical community access. The WIYN telescope is owned and operated by a collaboration among three institutions, University of Wisconsin, Indiana University, and NOAO. (Yale University withdrew from the consortium in 2014.) NOAO's share of the WIYN telescope time for public access is 40 percent.

The PRC recommendations are being implemented consistent with the plan presented in the solicitation for management and operation of NOAO which was published in July 2013 (see recompetition discussion below). The 2.1-meter telescope is no longer available for community access (since September 2014), and proposals from outside organizations to take over its operation are being evaluated. Starting in FY 2016, NSF funding for the Mayall and WIYN telescopes will be removed from the NOAO base operations and maintenance budget. Any subsequent NSF support for these telescopes will be as special projects with supplemental funding to NOAO.

Total Obligations for NOAO

(Dollars in Millions)

	FY 2014	FY 2015	FY 2016	ESTIMATES[1]				
	Actual	Estimate	Request	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021
NOAO Base O&M	$18.50	$20.00	$17.50	$17.76	$18.29	$18.83	$19.40	$19.98
Tucson Operations	*10.50*	*12.00*	*8.00*	*8.24*	*8.49*	*8.74*	*9.00*	*9.27*
Chilean Operations	*7.00*	*7.00*	*8.50*	*8.49*	*8.74*	*9.00*	*9.27*	*9.55*
Kitt Peak Operations	*1.00*	*1.00*	*1.00*	*1.03*	*1.06*	*1.09*	*1.13*	*1.16*
Special Projects (WIYN and Mayall)	5.50	5.50	4.25	4.50	1.00	1.00	1.00	1.00
LSST Development[2]	1.50	-	-	-	-	-	-	-
Total, NOAO	**$25.50**	**$25.50**	**$21.75**	**$22.26**	**$19.29**	**$19.83**	**$20.40**	**$20.98**

Totals may not add due to rounding.

[1] Outyear funding estimates are for planning purposes only and are consistent with the amounts in the NOAO Management Solicitation, NSF 13-582, and with potential partnerships. The current cooperative agreement ends in FY 2015.

[2] Funding for LSST development is zero after FY 2014 because the start of construction through the MREFC account began in late FY 2014.

Partnerships and Other Funding Sources: The managing organization for NOAO is the Association of Universities for Research in Astronomy (AURA), Inc., which is comprised of 39 U.S. member institutions and seven international affiliate members. A key NOAO partnership is ongoing with the Department of Energy (DOE) to conduct a survey of the southern sky to investigate the nature of dark energy. The five-year Dark Energy Survey began operation in August 2013 on the CTIO 4-meter Blanco telescope. Along with the WIYN telescope mentioned above, NOAO is a partner in the 4.1-meter SOAR (Southern Astrophysical Research) telescope at CTIO. SOAR partners include the University of North Carolina, Chapel Hill; Michigan State University; and the Ministério da Ciência, Tecnologia, e Inoviçao of Brasil.

A large number of U.S. universities support their own astronomical facilities at KPNO and CTIO with reimbursed services provided by NOAO. Development of new telescopes, instrumentation, and sensor techniques is done in partnership with universities and with industry through subawards to aerospace, optical fabrication, and information technology companies. NOAO leverages NSF support with funding from other federal agencies and non-federal sources. NOAO typically receives approximately $10.0 million each year for reimbursed services from partnerships and tenant observatory support, from the Kitt Peak Visitors Center, and from grants from other federal agencies.

Education and Public Outreach: NOAO supports U.S. education goals by promoting public understanding and support of science and by providing education and training at all levels. Over 200 U.S. and foreign graduate students observe on NOAO telescopes yearly and a significant fraction of the observations contribute to Ph.D. dissertations. The observatories introduce undergraduate students to scientific research by providing stimulating environments for basic astronomical research and related technologies through NSF's Research Experiences for Undergraduate Students (REU) program. NOAO has a diverse education program, visitors centers, and a web-based information portal at www.noao.edu.

NOAO Base O&M: $17.50 million; -$2.50 million from FY 2015.

Tucson Operations: $8.0 million; -$4.0 million from FY 2015: Tucson operations covers the headquarters, offices, laboratories, and workshops in Tucson, Arizona. The reductions in FY 2016 are consistent with the solicitation for management and operation of NOAO, and have been described in NOAO planning documents in FY 2014 and FY 2015.

Chilean Operations: $8.50 million; +$1.50 million from FY 2015: This supports administration and labs in La Serena, Chile and mountain operations on Cerro Tololo and Cerro Pachón. The increase in FY 2015 is to make the Chilean operation more robust to respond to equipment failures in a timely way.

Kitt Peak Operations: $1.0 million; no change from FY 2015: This provides support for basic infrastructure on the mountain for the benefit of the tenants. All facilities on the mountain are accounted as tenants.

Special Projects (WIYN and Mayall): $4.25 million; -$1.25 million from FY 2015.

WIYN telescope: $1.0 million; no change from FY 2015: NASA has identified the WIYN telescope as the preferred platform for an extreme precision Doppler spectrometer as a facility instrument for exoplanet follow up research. This instrument is the key component of a NASA-NSF partnership in Exoplanet Observational Research (NN-EXPLORE), which may begin as early as FY 2015 using existing instrumentation on WIYN.

Mayall Telescope: $3.25 million; -$1.25 million from FY 2015: Discussions regarding potential partnerships are underway.

Management and Oversight

- NSF Structure: An NSF program officer in the Division of Astronomical Sciences (AST) provides continuing oversight, including consultation with an NSF Program Review Panel of external reviewers that meets twice a year. The program officer reviews detailed annual program plans, annual long range plans, quarterly technical and financial reports, and annual reports submitted by NOAO. The NSF program officer also attends AURA governance committee meetings. Governance committees are formed from the national astronomical community and provide additional avenues for input of community priorities and concerns. The AST program officer works closely with other offices at NSF, particularly the Office of General Counsel, and the Division of Acquisition and Cooperative Support and the Large Facilities Office in the Office of Budget, Finance, and Award Management.
- External Structure: AURA is the managing organization for NOAO. The NOAO director reports to the president of AURA, who is the principal investigator on the FY 2009 NSF cooperative agreement. AURA receives management advice from an observatory council composed of members of its scientific and management communities. NOAO employs separate visiting and users committees for the purposes of self-evaluation and prioritization. The visiting committees, composed of nationally

prominent individuals in science, management, and broadening participation, review for AURA all aspects of the management and operations of the observatories. Users committees, composed of scientists with considerable experience with the observatories, review for the NOAO director all aspects of user experiences at the observatory.

- Reviews: In addition to reviews held mid-way through all cooperative agreements, NSF conducts both periodic and ad hoc external reviews of AURA management. A Business Systems Review was carried out in FY 2013.

Renewal/Recompetition/Termination

A management review of AURA's performance was carried out in August 2006. In response to the review, the National Science Board extended the previous cooperative agreement with AURA for eighteen months, through September 30, 2009. A proposal for renewal of the cooperative agreement was received from AURA in December 2007 and underwent review in 2008. The National Science Board authorized a new cooperative agreement with AURA for the management and operation of NOAO for the period October 1, 2009, through March 31, 2014, which has been extended to September 30, 2015. The extension is to accommodate a competition for the management and operation of NOAO and will allow for the implementation of PRC recommendations that will alter the scope of work to be managed under a new cooperative agreement to begin in FY 2016. A solicitation was published in July 2013 (NSF 13-582) for competition for the management of NOAO, with the new management award slated to begin at the start of FY 2016.

NATIONAL RADIO ASTRONOMY OBSERVATORY

$82,080,000
-$1,230,000 / -1.5%

National Radio Astronomy Observatory
(Dollars in Millions)

FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change over FY 2015 Estimate Amount	Percent
$77.41	$83.31	$82.08	-$1.23	-1.5%

The National Radio Astronomy Observatory (NRAO) conceives, designs, builds, operates, and maintains state-of-the-art radio telescopes used by scientists from around the world. Operating synergistically with optical, infrared, and x-ray telescopes, NRAO facilities enable discovery over a remarkably broad range of key problems in modern astrophysics that reach from within our solar system to the most distant galaxies in the universe. Using NRAO observing capabilities and data archives, scientists: carry out precision cosmological measurements; test fundamental physics; probe deep into the earliest, most intense, and optically obscured phases of planet, star, galaxy, and black hole formation; reveal the cool gas from which stars form; provide essential tools for studying magnetic fields and high-energy cosmic phenomena; and seek to detect gravitational waves.

As a Federally Funded Research and Development Center, headquartered in Charlottesville, Virginia, NRAO operates major radio telescopes in Green Bank, West Virginia; near Socorro, New Mexico; and at 10 telescope array sites spanning the U.S. from the Virgin Islands to Hawaii. NRAO is also the North American implementing organization for the international Atacama Large Millimeter/submillimeter Array (ALMA). These ground-based observing facilities for radio astronomy are available to any qualified researcher, regardless of affiliation or nationality, on the basis of scientific, merit-reviewed proposals. NRAO facilities annually serve over 1,500 users worldwide; moreover, growing demand for ALMA has resulted in the most proposals ever received for an astronomical facility in response to a single proposal call. NSF does not provide individual investigator awards targeted specifically for use of NRAO facilities, but many users are supported through NSF or NASA grants to pursue scientific programs that require use of NRAO facilities.

Including the ALMA operations staff located at NRAO, Observatory staff consists of 474 full-time equivalent positions (FTEs) in the operations and maintenance components of the Observatory: 293 in telescope operations, 23 in science support and research, 23 in development programs, 76 in computing and data management, 33 in administrative services, and 26 in the Director's office. In addition, the NRAO managing organization, Associated Universities, Inc. (AUI), employs the local ALMA Operations staff in Chile, currently consisting of approximately 200 FTEs.

In 2010, the National Research Council conducted its sixth decadal survey in astronomy and astrophysics. In their report, *New Worlds, New Horizons in Astronomy and Astrophysics,*[18] the NRC committee recommended that "NSF-Astronomy should complete its next senior review before the mid-decade independent review that is recommended in this report, so as to determine which, if any, facilities NSF-AST should cease to support in order to release funds for (1) the construction and ongoing operation of new telescopes and instruments and (2) the science analysis needed to capitalize on the results from existing and future facilities." In response to this recommendation, the Division of Astronomical Sciences (AST) conducted a community-based review of its portfolio. The resulting Portfolio Review

[18] www.nap.edu/catalog.php?record_id=12951

Committee (PRC) report, *Advancing Astronomy in the Coming Decade: Opportunities and Challenges,*[19] was released in August 2012 and included recommendations about all of the major AST telescope facilities.

The PRC Committee report gave very high priority ranking to two NRAO telescopes: ALMA and the Karl G. Jansky Very Large Array (VLA). The Robert C. Byrd Green Bank Telescope (GBT) and the Very Long Baseline Array (VLBA) were recommended for divestment from AST funding because of less compelling mapping onto the science questions of the 2010 decadal survey. In FY 2012 and FY 2013, AST began to engage actively in facility partnership discussions for GBT and VLBA with other federal agencies and with university-based groups. The GBT and VLBA were partitioned from the NRAO management competition to facilitate other unconstrained partnership discussions separate from the open management competition. In FY 2014, AST continued these other partnership discussions, and NSF brought a general engineering contractor on-board for all its engineering and environmental reviews. In FY 2015, that contractor is producing feasibility reports for divestment alternatives, which will provide the results of baseline structural and environmental surveys of the GBT and VLBA. Should viable options be identified and the decision made to divest, NSF will embark on formal reviews (in FY 2015 and FY 2016) to evaluate environmental impacts of these alternatives, including potential impacts of partnership opportunities.

Total Obligations for NRAO

(Dollars in Millions)

	FY 2014	FY 2015	FY 2016	ESTIMATES[1]				
	Actual	Estimate	Request	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021
Operations & Maintenance	$43.14	$43.14	$41.73	$32.00	$32.96	$33.95	$34.97	$36.02
Telescope Operations	*17.63*	*17.63*	*17.07*	*13.09*	*13.48*	*13.88*	*14.30*	*14.73*
Development	*2.73*	*2.73*	*2.60*	*1.99*	*2.05*	*2.12*	*2.18*	*2.24*
Science Operations	*5.37*	*5.37*	*5.16*	*3.96*	*4.08*	*4.20*	*4.33*	*4.46*
Administrative Services	*13.99*	*13.99*	*13.59*	*10.42*	*10.73*	*11.05*	*11.38*	*11.73*
Directors Office	*3.42*	*3.42*	*3.31*	*2.54*	*2.62*	*2.70*	*2.78*	*2.86*
ALMA Operations	34.27	40.17	40.35	43.25	44.55	45.88	47.26	48.68
Total, NRAO	**$77.41**	**$83.31**	**$82.08**	**$75.25**	**$77.51**	**$79.83**	**$82.23**	**$84.70**

Totals may not add due to rounding.

[1] Outyear funding estimates are for planning purposes only and are consistent with forecasts in the solicitation for the NRAO management competition, which was released in FY 2014 (NSF 14-568). The current cooperative agreement ends in September 2015.

The overall funding request for NRAO in FY 2016 decreased slightly from FY 2015. The planned ramp up to full ALMA operations, including projected increases in power costs in Chile, is the only increase. Anticipated reduced funding for the rest of NRAO in FY 2017 reflects the partitioning of the VLBA and GBT whose management and operation will be under separate consideration.

Partnerships and Other Funding Sources: NRAO supplements AST support with funding provided by other NSF sources, other federal agencies, and non-federal sources. In FY 2014, NRAO received approximately $280,000 from non-AST sources at NSF, $3.10 million from other federal agencies, and $4.55 million from U.S. universities, foreign scientific and technical institutes, and other non-federal and industrial sources. The development of new telescopes, instrumentation, and sensor techniques is conducted in partnership with relevant industries through competitive sub-awards to various large and small aerospace companies, radio antenna manufacturing firms, and specialized electronics and computer

[19] www.nsf.gov/mps/ast/ast_portfolio_review.jsp

hardware and software companies.

Education and Public Outreach: NRAO supports a comprehensive outreach program that makes information about radio astronomy available to the public.[20] With over 150 students involved per year, NRAO facilities are used by graduate students carrying out dissertation research and work experience programs and by undergraduate students participating in the Research Experiences for Undergraduates (REU) program. NRAO sites also support visitor and education centers and conduct active educational and public outreach programs. The Green Bank Science Center and the visitor center at the VLA together attract over 60,000 public visitors each year.

Telescope operations, $17.07 million: This encompasses support for direct telescope and array operations of GBT, VLA, and VLBA, including maintenance, infrastructure upgrades, and telescope management.

Development, $2.60 million: Development programs include next generation electronics and detectors for radio astronomy, making fundamental contributions to materials science, the physics of quantum detectors, electromagnetics, photonics, and radio propagation.

Science operations, $5.16 million: This area includes telescope time allocation, staff research, science training and education, and science community outreach.

Administrative services, $13.59 million: This includes internal common costs used to allocate common and management expenses across the total pool of observatory activity, such as business services, utilities, and other facility costs at the operating locations, observatory management, and the library.

Director's office, $3.31 million: This includes support for the Director's office, news and public information, and managing organization costs.

ALMA Operations, $40.35 million: NRAO is engaged in construction and operation of the international ALMA Observatory, which is in the very final stages of construction funded through the Major Research Equipment and Facilities Construction account. The remaining construction activity will be completed before the beginning of FY 2016. Early operations funding for ALMA began in FY 2005 and ramps up to full operations in FY 2017. A funding profile through FY 2015 was authorized by the National Science Board in February 2011.

As part of ALMA Operations, in 2006 NRAO created the North American ALMA Science Center (NAASC) to support the broad user community in fully realizing the scientific capabilities of ALMA. NAASC is increasing its activity in conjunction with the ramp up in ALMA operations. NAASC serves two key functions: (1) supporting basic ALMA operations as an ALMA Regional Center, providing day-to-day support for ALMA operations carried out in Chile, and (2) providing easy access and strong support to the broad astronomical community that will be using ALMA. NAASC organizes summer schools, workshops, and courses in techniques of millimeter and submillimeter astronomy.

Management and Oversight

- NSF Structure: In consultation with community representatives, dedicated AST program officers carry out continuing oversight and assessment for NRAO and ALMA by making use of detailed annual program plans, long-range plans, quarterly technical and financial reports, and annual reports submitted to NSF. AST program officers participate in the international ALMA Board and attend AUI/NRAO governance and advisory committee meetings. To address issues as they arise, AST

[20] https://public.nrao.edu/

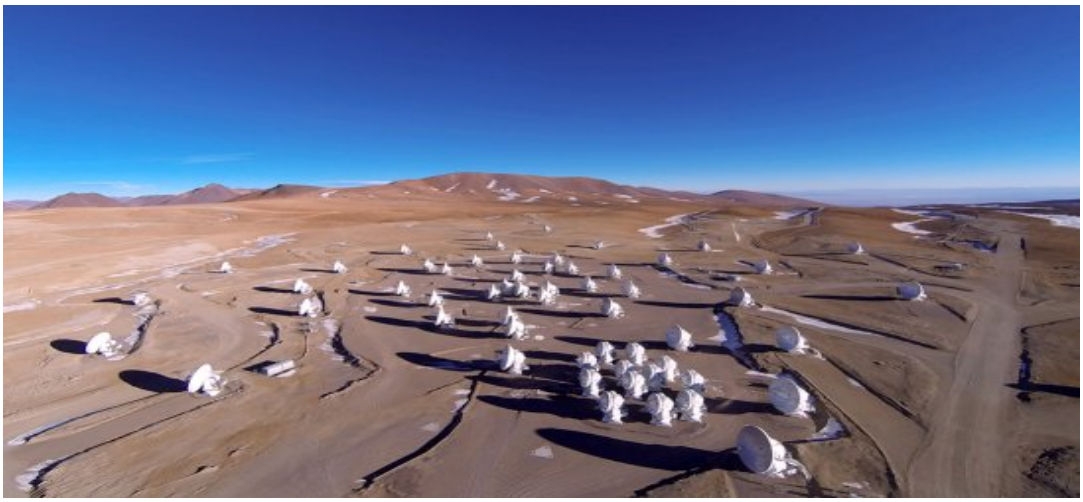
works closely with other NSF offices, such as the Office of General Counsel, the Office of International and Integrative Activities, the Division of Acquisition and Cooperative Support, and the Large Facilities Office in the Office of Budget, Finance, and Award Management.

- External Structure: Management is through a cooperative agreement with AUI. AUI manages the observatory through its own community-based oversight and users committees. The NRAO director reports to the president of AUI. Oversight of the international ALMA project is vested in the ALMA Board, which includes a member from NSF; coordination and management of the merged international efforts are the responsibility of the Joint ALMA Observatory (JAO) whose staff includes an ALMA director. An international ALMA review committee advises the ALMA Board.
- Reviews: NSF conducts annual reviews of the NRAO Program Operating Plan and strategic planning documents, ALMA construction and operations, and the AUI Management Report. A Business Systems Review and mid-term Management Review were conducted in FY 2012.

Renewal/Recompetition/Termination

A management review of AUI's performance and plans for NRAO and ALMA was carried out in 2008. In response, the National Science Board authorized renewal of the cooperative agreement with AUI for the management and operation of NRAO for the period October 1, 2010 through September 30, 2015. Following a solicitation issued in FY 2014 (NSF 14-568), competition of NRAO and ALMA management and operation is underway for a new cooperative agreement to begin in early FY 2016. The current award term will undergo a concomitant one-year extension.

As announced in a Dear Colleague Letter, NSF 13-074, NSF has partitioned GBT and VLBA from the NRAO management competition in order to sustain the scientific and operational synergies of North American ALMA and the VLA, while increasing flexibility for exploring cost-efficient operational models and sustainable partnerships for GBT and VLBA.



The Atacama Large Millimeter/submillimeter Array (ALMA) is in science operations following the completion of all major construction activities in 2014. ALMA, an international partnership between North America, Europe, and East Asia, provides orders-of-magnitude improvement in observing sensitivity and image quality over previous facilities. *Credit: NRAO/AUI.*

OTHER FACILITIES FUNDING

Major Research Equipment and Facilities Construction Account Projects

The MREFC account supports the acquisition, construction, and commissioning of major research facilities and equipment that provide unique capabilities at the frontiers of science and engineering. Projects supported by this account are intended to extend the boundaries of technology and open new avenues for discovery for the science and engineering community. Initial planning and design, and follow-on operations and maintenance costs of the facilities are provided through the Research and Related Activities account (R&RA) and Education and Human Resources (EHR) account.

For information on projects funded through this account, refer to the MREFC chapter of this Budget Request.

Preconstruction Planning

Within the R&RA account, funds are provided for preconstruction studies for prospective large facility projects. This funding generally supports such activities as design, cost estimates, and other actions that prepare potential projects for oversight review, agency decision milestones, and potential implementation.

NSF-WIDE INVESTMENTS

Major FY 2016 Investments:

STEM Education:

Other NSF-wide Activities:

NSTC Activities

CYBER-ENABLED MATERIALS, MANUFACTURING, AND SMART SYSTEMS (CEMMSS)

$256,950,000
+$25,490,000 / 11.0%

Overview

The Cyber-enabled Materials, Manufacturing, and Smart Systems (CEMMSS) investment aims to integrate a number of science and engineering activities across NSF, including breakthrough materials, advanced manufacturing, robotics, and cyber-physical systems (CPS), in response to the Materials Genome Initiative (MGI), Advanced Manufacturing Partnership (AMP), and National Robotics Initiative (NRI). Through CEMMSS-funded research, materials with unique properties and functionality are being discovered and developed more reliably and efficiently via the integration of theory, modeling and simulation, data analytics, and experiments. These new materials can in turn be fashioned into objects, structures, and systems embedded with computational intelligence, thereby transforming today's static systems, processes, and edifices into adaptive smart systems through the use of advanced manufacturing strategies also supported through CEMMSS.

The smart systems of tomorrow and the materials from which they will be composed will vastly exceed those of today in terms of adaptability, autonomy, functionality, efficiency, reliability, safety, usability, recoverability, and recyclability. These advances have the potential to accelerate scientific and engineering discoveries to address key national and societal challenges critical to U.S. security and competitiveness.

Total Funding for CEMMSS
(Dollars in Millions)

FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
$255.94	**$231.46**	**$256.95**

Goals

Goal 1: Science and Engineering

CEMMSS will establish a scientific base, a codified knowledge base, and shared principles for designing, manufacturing, and deploying cyber-enabled smart engineered systems and advanced materials.

Goal 2: Education, Workforce Development, and Community Building

CEMMSS investments will lead to the education of a cadre of high-caliber disciplinary and interdisciplinary researchers and develop a vibrant workforce so as to ensure a pipeline of talent and a growing community in these critical areas.

Goal 3: Research Infrastructure Development

CEMMSS will develop the critical research infrastructure that can be used to discover, test, refine, and validate the advanced materials, designs, and manufacturing and development methods so as to enable the deployment of smart systems.

Approach

The CEMMSS framework of bringing together researchers focused on breakthrough materials, advanced manufacturing, robotics, and cyber-physical systems is expected to increase collaboration and communication among these research communities. This will lead to enhanced disciplinary and interdisciplinary research. CEMMSS funds research that couples modeling and theory with experimentation, thereby shortening the time and resources required for the discovery and understanding of new materials. Such efforts will aid in the transformation of static systems, processes, and edifices into

adaptive, widespread smart systems with embedded computational intelligence that can sense, adapt, and react. Success in CEMMSS will drive transformations that address the pressing technological challenges facing the Nation, promoting U.S. economic competitiveness.

Programmatic

CEMMSS is developing a portfolio that synchronizes activities across four main research areas – breakthrough materials, advanced manufacturing, robotics, and cyber-physical systems – and encourages interdependencies and common research elements to surface and be exploited at each subsequent stage of the evolution of the program.

Organizational

CEMMSS leadership is shared across the relevant division directors in the Computer and Information Science and Engineering (CISE), Engineering (ENG), and Mathematical and Physical Sciences (MPS) directorates. The CEMMSS coordination team is comprised of program directors from the CISE, ENG, MPS, and Biological Sciences (BIO) directorates. This group is charged with developing and implementing the suite of CEMMSS activities. The team is also working with internal and external program evaluation experts to help develop a set of metrics by which program progress can be assessed over time.

Scope

Numerous CEMMSS interdisciplinary connections already exist at NSF. Many are pairwise and expanding, such as robotics and manufacturing; materials and manufacturing; cyber-physical systems and robotics; cyber-physical systems and manufacturing materials; cyber-physical systems and advanced biomanufacturing; manufacturing and the biological sciences; robotics and the biological sciences; and advanced manufacturing and technician education. NSF has sponsored, and will continue to hold, community-building workshops. The intention is to drive new research directions. This will be achieved through a combination of new solicitations and Dear Colleague Letters (DCLs). CEMMSS currently includes many interagency activities, and new cross-agency partnerships are continuously being developed. Industry partnerships also are a key element in CEMMSS's success; industry and venture capital groups will be invited to workshops and principal investigator (PI) meetings. NSF also expects that international activities will become increasingly relevant over the period of time that CEMMSS is an NSF-wide investment area. CEMMSS presents a unique opportunity to accelerate integrative research and educational activities. The interaction of research ideas that is promoted by CEMMSS multiplies their impact across multiple research communities.

Investment Framework

CEMMSS Funding by Directorate

(Dollars in Millions)

Directorate	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
Biological Sciences	$4.75	$4.99	$5.48
Computer and Information Science and Engineering	85.00	89.00	94.11
Education and Human Resources	0.30	-	-
Engineering	97.79	96.81	107.52
Mathematical and Physical Sciences	68.10	40.66	49.84
Total	**$255.94**	**$231.46**	**$256.95**

Totals may not add due to rounding.

FY 2014 – FY 2015

The specific CEMMSS investments in Advanced Manufacturing, CPS, Designing Materials to Revolutionize and Engineer our Future (DMREF), and NRI continued to focus on increased integration of the highest priority areas, such as those related to materials and manufacturing, and developing smart systems.

Biomanufacturing emerged as an important emphasis research area in the overall portfolio of advanced manufacturing research. ENG and BIO jointly funded a National Academy of Sciences (NAS) study on the Industrialization of Biology that focuses on the research, education, and infrastructure needs to enable advances in biomanufacturing; a final report is expected by the end of FY 2015. NSF and the National Institute of Standards and Technology (NIST), along with the European Commission, are holding a workshop in FY 2015 on the development of standards that will enable data sharing and automation in advanced biomanufacturing and engineering of biology. In FY 2014, ENG and BIO collaborated on a DCL that solicited new Industry/University Cooperative Research Centers (I/UCRC) in the area of advanced biomanufacturing, and the first planning grant under this DCL will be funded in FY 2015.

In FY 2014, the CPS program solicitation was updated to incorporate results from a gap analysis of the program's portfolio as well as community feedback. Additionally, the CPS solicitation included, for the first time in FY 2014, the Department of Homeland Security (DHS) and the Department of Transportation (DOT), and the program is continuing to expand its agency partners in FY 2015. Over 40 projects were supported by CPS in conjunction with DHS and DOT in FY 2014.

The DMREF program developed a multi-directorate solicitation in FY 2014 that is supporting awards in FY 2015 that integrate theory, simulation, and/or cyber-enabled data analytics with synthesis and characterization experiments in an iterative manner. These awards will accelerate new materials discovery and understanding, design, and innovation.

The NRI solicitation emphasized a call for solutions integrated across the CEMMSS disciplines, especially those that enhance manufacturing processes, and those that have the broadest impacts. CEMMSS will increase the use of the "transition to practice" option (e.g., through the interagency CPS solicitation). NSF will continue to work with other agencies, as well as with industrial/commercial organizations, in support of NRI challenges and contests programs that foster the implementation of systems and devices to achieve real-world tasks in unconstrained environments.

CEMMSS programs continue to hold technical workshops to advance research goals. For example, CPS efforts were informed by a series of FY 2014 community workshops exploring foundational research challenges in key national priority areas, including energy, transportation, and medical devices. CPS will hold a workshop in FY 2015 exploring the role of CPS in Internet of Things (IoT)-enabled smart city applications.

DMREF held joint workshops with the Department of Energy (DOE) in areas of critical importance to the development of the field. Some of these workshops were co-organized with other agencies as addressed in the recent MGI Strategic Plan.[1] To spotlight opportunities for mathematical sciences research in connection with DMREF, MPS will support a Symposium on Mathematical and Computational Aspects of Materials Science in March 2015.

NRI-related workshops have focused on: a) Opportunities in Robotics, Automation, and Computer Science; b) Robot Planning in the Real World: Research Challenges and Opportunities; and c)

[1] www.whitehouse.gov/sites/default/files/microsites/ostp/NSTC/mgi_strategic_plan_-_dec_2014.pdf

Advancement of Field Robots for Ebola Response (organized by the Office of Science and Technology Policy (OSTP) as part of the Adminstration's response to Ebola). In FY 2015, NRI will convene a workshop titled, "Locomotion and Manipulation: Why the Great Divide?," encouraging collaboration between the research communities of locomotion and manipulation, particularly in areas of planning, control, perception, and design. Additionally, CISE will hold a workshop in FY 2015 to bring together researchers in robotics and cyber-physical systems to develop a set of foundational problems common to the two communities.

CEMMSS programs held annual meetings of NSF-funded researchers as a means to build the CEMMSS research community. Additionally, these meetings of principal investigators (PI) allow researchers to describe research advances and identify emerging directions, form new collaborations, learn about new funding opportunities across the federal government, and interact with stakeholders from other NSF programs and federal agencies. The following PI meetings occurred (or are planned) during FY 2014–2015:

- CPS held its annual PI meeting in fall 2014, and plans for its fall 2015 PI meeting to include a session with representatives from NSF center-scale activities (e.g., Engineering Research Centers, Science and Technology Centers, and I/UCRC).
- DMREF held a joint PI meeting with the DOE MGI meeting of grantees in January 2015.
- NRI held its second annual PI meeting in fall 2014 to advance cross-project interaction and collaboration; establish safety standards and risk metrics; and plan for project transitions to include additional partners.

As mentioned earlier, interagency and industrial partnerships are important to the success of CEMMSS. These interagency activities include: a) recruitment of additional government agencies; b) development of evaluation methods for cross-agency projects; c) implementation of smart systems challenges and contests; and d) program assessment and planning meetings for subsequent solicitations.

In response to the Advanced Manufacturing Partnership 2.0 (AMP 2.0), NSF and the Department of Commerce (DOC) launched a new manufacturing technology consortium in FY 2014 to ensure the federal government maintains leading-edge insight into emerging manufacturing technology trends. In FY 2015, NSF plans to fund up to two new I/UCRC or clusters in advanced manufacturing to help address key technological gaps on cross-cutting manufacturing technologies – advanced sensors, digital manufacturing, and composites – that the AMP highlighted as critical for U.S. competitiveness. Additionally, NSF will identify opportunities for utilizing supplemental awards to CEMMSS grantees to enable direct collaboration with at least two of the newly created Institutes for Manufacturing Innovation (managed by DOD and DOE) and/or DOC's Investing in Manufacturing Communities Partnership (IMCP) initiative. NSF will continue to participate in, or host, interagency-supported workshops to provide insight on opportunities, needs, and scientific barriers facing the broader advanced manufacturing sectors. NSF will use the results of these events to connect ongoing NSF research activities to related mission agency efforts, and to help set research agendas for FY 2016 and beyond.

Through the National Science and Technology Council (NSTC) Subcomittee for Networking and Information Technology Research and Development (NITRD) CPS Senior Steering Group (SSG), NSF co-leads a multi-agency, multi-sector comprehensive approach to solving the most difficult cross-cutting R&D challenges. The CPS SSG provides leadership across the government in CPS R&D, and allows NSF to cooperate with other agencies on research portfolio development. NSF also explored partnerships with mission agencies to establish linkages between NSF-funded projects and mission agency-funded contracts/cooperative agreements to further the development and deployment of smart systems. For example, these activities led to additional agencies partnering on the CPS program solicitation, as described above.

In addition, through participation in the NSTC Subcomittee on the Materials Genome Initative (SMGI), NSF helped develop an interagency strategic framework for MGI in FY 2014. As was noted above, NSF organized technical workshops with other federal agencies based on this framework.

Education and workforce development are essential to this emerging field. In FY 2014, the Education and Human Resources (EHR) directorate, through its Advanced Technological Education (ATE) program, supported a collaborative center that provides technical support to grantees of the Department of Labor's Trade Adjustment Assistance Community College and Career Training (TAACCCT) program. NSF conducted internal and external portfolio analyses of its education investments at the technician, undergraduate, and graduate levels to identify gaps and opportunities for further cross-directorate and interagency cooperation related to education and workforce development in CEMMSS.

Based on this gap analysis and portfolio evaluation, NSF is developing a broad CEMMSS education framework in connection with the Improving Undergraduate STEM Education (IUSE) agency-wide framework, and the NSF-wide Strategic Plan for Graduate Education which is under development. A key aspect of this analysis is a NAS study on CPS education; initially funded in FY 2013; a final report is anticipated in FY 2015.

In FY 2014, NSF held a first-of-its-kind workshop aimed at upper-level graduate students and recent Ph.D. graduates focused on the CPS community. Given the success of this activity, NSF will hold a similar workshop in FY 2015. The objectives of this workshop are to identify new paradigms, challenges, and opportunities that will define future research directions for CPS; facilitate advances in closely related disciplines such as energy, transportation, and healthcare; and nurture and grow the CPS field by fostering new collaborations among young researchers. CPS will hold another workshop to discuss challenge problems in cyber-physical systems with an aim to engage secondary and undergraduate students. The NRI solicitation for FY 2014 and FY 2015 included language encouraging activities involving the participation and training of students and requesting reviewers to assess the potential for involvement of motivated young roboticists in accomplishing the research goals of the proposed projects.

Research infrastructure is also essential. NSF focused on solidifying plans for data and software infrastructure with an emphasis on engaging the community in a discussion on requirements and incentives for use. Pilot investments in data and software infrastructure will be made. NSF will hold a community workshop on CPS testbeds in FY 2015 to help identify the most pressing needs and most promising sectors for CPS. NSF works with the CPS Virtual Organization (VO) to distribute testbed software, including simulation and other tools. CPS will also fund at least two projects focused on community testbeds/infrastructure.

FY 2016 Request

- In FY 2016, NSF expects to build toward a cyber-manufacturing program to enable research on the networked integration of manufacturing machines, equipment and systems into an increasingly accessible manufacturing service infrastructure. This program will leverage exsiting core programs within ENG, including Design of Engineering Material Systems (DEMS), Manufacturing Machines and Equipment (MME), and Manufacturing Enterprise Systems (MES), as well as cross-directorate activities including CPS and NRI.
- NSF plans to support research in advanced biomanufacturing. This research will focus on studying theories and technologies of design, engineering, and manufacturing of bio-related (natural or synthetic) products, such as cells and cell-based therapeutic products (i.e. individualized tissues and organoids), or devices with biomaterials and/or cells as components. It will leverage the Biomedical Engineering and Biotechnology and Biochemical Engineering programs in ENG, and build on groundbreaking discoveries, many of which have been supported by NSF in the past, such as 3D additive manufacturing, genome editing, systems and synthetic biology, stem cell biology,

computational modeling, micro- and nanofabrication, and tissue engineering and regenerative medicine. The program holds the promise of enabling the manufacturing of products for low-cost therapeutic research, personalized therapeutic products, and high-value chemicals and materials.

- In FY 2016, NSF expects to continue its interagency collaborations in the area of engineering biology related to advanced biomanufacturing. ENG and BIO will continue to collaborate in funding a new I/UCRC in the area.
- With an interagency CEMMSS program established, CPS will increase its focus on Transition To Practice (TTP) as part of its strong foundational program. This will include funding another I/UCRC in CPS, and a session at the annual CPS PI meeting describing programs that enable TTP and showcasing successful CPS TTP efforts.
- Annual workshops for DMREF PIs will be held to build the community and to identify challenges and successes associated with the integrated and iterative approach to DMREF projects. Industrial participants, venture capitalists, and representatives of professional societies will be invited. Joint workshops with DOE PIs will be continued.
- Joint meetings will be held of co-robot and autonomous robot scientists and engineers from industry and academe to facilitate the application and transfer of known technologies in each domain that satisfy the constraints of the other.
- NSF expects to continue to work with other federal agencies as well as industrial/commercial organizations in support of NRI challenges and contests that foster the implementation of systems and devices to achieve real-world tasks in unconstrained environments.
- Additionally, the NRI solicitation will be updated to encourage the engagement of projects in cross-disciplinary workforce development (academic and industrial) as a key consideration in addressing the broader impact criteria.
- On the basis of the NAS report on CPS education anticipated in FY 2015 as described above, NSF will hold a workshop with the goal of jumpstarting activities and funding EArly-Concept Grants for Exploratory Research (EAGER) awards to members of the community.

FY 2017 – FY 2018

As CEMMSS makes significant progress, NSF will develop several comprehensive, integrated programs across the focus areas, e.g., in cyber-manufacturing, advanced materials and smart systems, to encourage new connections, discoveries and/or emerging fields of science and engineering. Progress towards CEMMSS goals will show evidence of: 1) an integrated and thriving ecosystem of cyber-enabled systems and advanced materials; 2) improved interdisciplinary education based on longitudinal study of education outcomes; and 3) advanced research infrastructure used by CEMMSS scientists and engineers. Through workshops and studies, NSF will regularly perform gap and opportunity analyses of emerging research areas to prioritize new CEMMSS programs.

NSF expects to continue to grow the cyber-manufacturing program, building upon CPS, NRI, and ENG core programs. CPS expects to continue funding CAREER awards, developing partnerships with other agencies, and supporting a transition to practice option in its solicitations. Awards that address the research infrastructure needs of the DMREF research community will also be made. NSF will hold annual PI meetings and workshops, and invite industry experts, venture capitalists, and representatives of professional societies to participate. Through NRI, safety standards and manufacturing performance for co-robots will be evaluated and validated. NSF will also host joint meetings of robot scientists and engineers from industry and academia to facilitate the transition of discoveries into practice.

As interagency partnerships mature, it is expected that hands-on research opportunities for NSF-sponsored students will increase (e.g., in the Manufacturing Innovation Institutes, and IMPC initiatives). NSF also expects to implement some of the recommendations included in the NAS study on CPS Education.

Evaluation Framework

NSF engaged the Science and Technology Policy Institute (STPI) in FY 2012 to assist with the development of a plan for an impact assessment of the CEMMSS initiative. This formulation has entailed discussions with CEMMSS management, including division directors, as well as CEMMSS program directors. Along the way, these discussions are also helping to formulate appropriate synergistic working groups, spanning NRI, CPS, Advanced Manufacturing, DMREF, and other related CEMMSS activities. The approach outlined below is being followed for CEMMSS program evaluation and assessment:

- A portfolio analysis was conducted to understand the scope and scheme of the overall CEMMSS initiative. The first step entailed gathering information and understanding the baseline portfolio, stakeholders, and related activities that NSF currently supports in the CEMMSS area. This included examining the current state of research in the research subfields and analyzing the various recommendations from federal advisory boards and the stakeholder communities on how future investments in CEMMSS areas should be focused.
- A logic model was developed to help NSF track progress toward the major scientific, educational, and infrastructure objectives of CEMMSS.
- Based on the results of the related activities described above, NSF will develop a plan for assessing progress across the CEMMSS science, engineering, education, and cyberinfrastructure activities.

By mid-FY 2015, the framework for the impact assessment will be developed. A report, including an implementation plan and metrics to measure success, will be submitted to the CEMMSS Coordination Team by the end of FY 2015.

The progress of the implementation of CEMMSS also was monitored and reviewed quarterly as part of a performance goal in FY 2014 and FY 2015. For more information about monitoring key program investments, see the FY 2014 Annual Performance Report in the Performance chapter.

CYBERINFRASTRUCTURE FRAMEWORK FOR 21ST CENTURY SCIENCE, ENGINEERING, AND EDUCATION (CIF21)

$143,060,000
+$14,100,000 / 10.9%

Overview

The Cyberinfrastructure Framework for 21st Century Science, Engineering, and Education (CIF21) investment accelerates and transforms the processes and outcomes of scientific discovery and innovation by providing and supporting the use of advanced cyberinfrastructure that enables new functional capabilities in computational and data-enabled science and engineering across all disciplines.

Science, engineering, and education continue to be transformed by increasingly comprehensive and scalable cyberinfrastructure that bridges diverse scientific communities and brings together theoretical, computational, experimental, and observational approaches. Large volumes of research data are being generated by scientific instruments, observing systems, surveys, mobile and embedded systems, as well as by publications, experiments, simulations, evaluations, and analyses. New and emerging data sources are also becoming available to the scientific community, through efforts such as digitizing collections and enhancing access to records and documents. In addition, scientists, using thousands of distributed scientific instruments, such as gene sequencers, sensors, and imaging devices, are generating many more small data archives and heterogeneous data sets at an unprecedented rate, creating the long tail of science, which is yet another data cyberinfrastructure challenge.

Complex scientific research problems, such as those under other NSF priority investments (e.g. Understanding the Brain (UtB) or Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS)) require advanced computational models, methods, and algorithms, including innovative, robust, and sustainable software that turn raw data into knowledge and action. CIF21 is a portfolio of activities that leverage ongoing cyberinfrastructure investments across NSF by coordinating and deploying common approaches and components to manage data and provide computational support to all areas of science and engineering while also developing new multidisciplinary research communities.

Total Funding for CIF21
(Dollars in Millions)

FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
$156.75	**$128.96**	**$143.06**

Goals

The overarching goals of CIF21 are:

- Support foundational research, and discovery and innovation; develop a deep mutual relationship between science and engineering users and developers of cyberinfrastructure to simultaneously advance new research practices and open transformative opportunities across all science and engineering fields;
- Enable data, computational, and digital capabilities and services by providing an integrated and scalable cyberinfrastructure that leverages existing and new components across all areas of science and engineering supported by NSF; and
- Ensure long-term sustainability and future growth for advanced cyberinfrastructure and CDS&E through community development, learning and workforce development, and transformation of practice.

Approach

The vision of CIF21 is to catalyze new thinking, paradigms, and practices in science and engineering by fostering a pervasive cyberinfrastructure that enables research at unprecedented scales, complexity, resolution, and accuracy. This cyberinfrastructure aims to integrate and coordinate computation, data, and experiments in novel ways, nationally and internationally.

Organizational Structure. The CIF21 organizational structure employs five interrelated groups to ensure that CIF21 continues to build upon NSF's history of providing leadership in the design, development, and use of the cyberinfrastructure required to transform science, engineering, and education in the 21st century:

- The NSF Advisory Committee for Cyberinfrastructure (ACCI) reviews cyberinfrastructure activities and programs across all of NSF, interacts with other NSF directorate advisory committees, and provides advice and strategic feedback on NSF plans and existing efforts.
- The Cyberinfrastructure Coordination and Leadership Group (CLG) coordinates and manages the broader NSF cyberinfrastructure investment portfolio, including CIF21 programs. This coordination and management includes developing solicitation guidance for common CIF21 programs, coordinating common CIF21 activities, and developing and maintaining an investment roadmap. CLG membership is designated by CIF21 Council members.
- The CIF21 Council of NSF assistant directors and office heads provides oversight and advice on strategic directions and programmatic scope for CIF21.
- The Advanced Cyberinfrastructure (ACI) division in the Computer and Information Science and Engineering (CISE) directorate provides leadership for CIF21 activities. This leadership includes developing coordinated CIF21 programs and solicitations and identifying common approaches for a scalable comprehensive cyberinfrastructure.
- As part of CIF21, the other CISE divisions and NSF directorates focus on foundational science, and engineering, as well as domain applications. This focus leverages cutting-edge cyberinfrastructure, and also advances critical techniques and technologies to address challenges in computational science and engineering, data management and analytics, and sustained software systems. For example, the Social, Behavioral, and Economic Sciences (SBE) directorate has a working group focused on development of user-friendly, large-scale, next-generation data resources and relevant analytical techniques to advance fundamental SBE research. A Geosciences (GEO) directorate working group oversees EarthCube, a community-driven data and knowledge environment for the geosciences. A long-standing working group in the Mathematical and Physical Sciences (MPS) directorate, with regular participation from other directorates including Engineering (ENG) and CISE, coordinates the Computational and Data-enabled Science and Engineering (CDS&E) program.

Scope. To guide the development of CIF21, the ACCI produced a set of six reports and recommendations for cyberinfrastructure.[1] These reports and recommendations have been critical in identifying new approaches and capabilities required to advance data,[2] computing infrastructure, software,[3] and workforce development for CIF21. In 2012, the Big Data Research and Development Initiative[4] was highlighted in CIF21, focusing research and development on new capabilities for data-intensive and data-enabled science. The Advanced Computing Infrastructure Strategic Plan,[5] published in 2012, focused on NSF leadership in creating and deploying a comprehensive portfolio of advanced computing infrastructure to accelerate the pace of discovery. Along with ongoing focused workshops and events, these reports and initiatives help to define and prioritize programs and activities within the CIF21 framework.

[1] NSF Advisory Committee for Cyberinfrastructure: www.nsf.gov/od/oci/taskforces/index.jsp
[2] A Vision and Strategy for Data in Science, Engineering and Education: www.nsf.gov/od/oci/cif21/DataVision2012.pdf
[3] Software for Science and Engineering; www.nsf.gov/od/oci/taskforces/index.jsp
[4] Administration Big Data Initiative: www.whitehouse.gov/sites/default/files/microsites/ostp/big_data_press_release_final_2.pdf
[5] Cyberinfrastructure for 21st Century Science and Engineering: Advanced Computing Infrastructure Vision and Strategic Plan

CIF21 uses a combination of solicitations, Dear Colleague Letters (DCLs), and focused workshops to fund the research, development, and deployment of cyberinfrastructure and related applications. The ubiquity of cyberinfrastructure requires partnerships and joint collaborations with industry, other federal agencies and international groups. Principal Investigator (PI) meetings, conferences, and workshops are used to reach out to new communities of researchers and educators.

Investment Framework

CIF21 Funding by Directorate
(Dollars in Millions)

Directorate	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
Biological Sciences	$6.16	$3.75	$8.39
Computer and Information Science and Engineering	85.00	84.21	84.21
Education and Human Resources	-	2.50	2.84
Engineering	12.00	10.00	10.00
Geosciences	15.25	11.00	14.21
Mathematical and Physical Sciences	32.34	11.50	16.15
Social, Behavioral, and Economic Sciences	6.00	6.00	7.26
Total	**$156.75**	**$128.96**	**$143.06**

Totals may not add due to rounding.

FY 2014 – FY 2015

Following the increased emphasis on domain-specific data intensive applications in FY 2014, the BIGDATA solicitation is being further expanded in FY 2015 to address issues of scope and scale. In FY 2015, NSF is holding a workshop on Big Data and replication of results. Reproducibility of results is an issue across the sciences, and the federal Networking and Information Technology Research and Development (NITRD) Big Data Senior Steering Group is spearheading development of this workshop to focus specifically on how Big Data can drive replicability and confirmation of hypotheses.

In FY 2014, the Data Infrastructure Building Blocks (DIBBs) solicitation was expanded to include participation by all the NSF directorates and the Office of International and Integrative Activities (OIIA). The seven NSF directorates and OIIA supported 16 pilot-demonstration and two early-implementation awards in FY 2014. During FY 2015, efforts in data infrastructure continue to focus on collaboration among all directorates and the formulation of a plan for developing a critical set of national-scale data archive pilots in FY 2016. DIBBs is increasing its scale and scope, emphasizing the value of sharing data beyond a specific institution to the wider science, engineering, and education communities. Investments in multi-campus and/or multi-institutional regional cyberinfrastructure sought to leverage high performance network paths among campuses, enabling integration of new data-focused services, capabilities, and resources to advance scientific discoveries, collaborations, and innovations.

In FY 2014, the Computational and Data-Enabled Science and Engineering (CDS&E) program, led by MPS, ENG, and CISE, was expanded to include new efforts and approaches for simulation and modeling, along with a specific focus on scaling. Prototypes in specific domains were developed with an emphasis upon collaboration across disciplines. The BIO and GEO directorates also participated informally in the proposal and review processes. A total of 71 CDS&E awards were made in FY 2014, half of which were co-funded between two or more divisions in the participating directorates. In FY 2015, additional prototype and proof-of-concept approaches for CDS&E will be developed. More involvement from all NSF directorates and other federal agencies will be pursued. Based on the results of continuing portfolio

analysis, the program will be structured to address emerging issues of scope and scale.

In FY 2014, EarthCube supported the planning phase for a science community-based governance structure, encouraging the participation and interaction of new geoscientists across domains, cyberinfrastructure researchers, and other agencies, as well as the private sector. The EarthCube All-Hands Meeting brought awardees and the broader EarthCube community together to make decisions on the governance framework, on mechanisms to coordinate projects and find common goals, on ways to articulate science drivers for infrastructure development, and on ways to approach the development of an integrated cyberinfrastructure architecture. In FY 2015, EarthCube will continue to support community coordination activities, such as research coordination networks, workshops, and other engagement mechanisms. These activities will broaden the base of users as well as the breadth of science conducted via EarthCube. Early efforts include development of common approaches including some level of integration and coordination across projects.

The Software Institutes for Sustained Innovation SI^2 program (led by CISE/ACI) issued a Dear Colleague Letter (DCL) jointly with the Science of Science and Innovation Policy (SciSIP) program (led by SBE) in FY 2014, calling for EArly-concept Grants for Exploratory Research (EAGER) and workshop proposals related to norms and practices for software and data citation and attribution, which could in turn incentivize sustained software in the long term. SI^2 continued to support software reuse across NSF. The program also began a community activity called "Working towards Sustainable Software for Science: Practice and Experiences (WSSSPE)," with two workshops at technical conferences, including the Supercomputing Conference 2014 (SC14), and a journal Special Issue with 19 papers. In FY 2015, SI^2 began working more closely with DIBBs to encourage proposals that have both software and data elements. SI^2 is also developing a supplement mechanism through which PIs can apply for additional funds to support creating and supporting open source software developed through general (non-SI^2) projects. These supplements are co-funded by the SI^2 program and the funders of the original award. This mechanism is replacing much of the existing software reuse activity funded as part of CIF21. Additionally, the SI^2 program will hold a PI meeting for grantees in FY 2015.

In FY 2014, NSF transitioned from IGERT to the NSF Research Traineeship (NRT) program. This new graduate education initiative is designed to encourage the development of new, potentially transformative, and scalable models for STEM graduate training that ensure that graduate students develop the skills, knowledge, and competencies needed to pursue a range of STEM careers. In this first year of the program, NRT specified one priority theme to address fundamental challenges advancing computation- and data-enabled science and engineering. This was directly aligned with CIF21. Based on the response to NRT in FY 2014, it is anticipated that this theme will continue in FY 2015, and a new set of five-year NRT awards is planned in this space.

In FY 2014, a revised and updated version of the Building Community and Capacity for Data-Intensive Research in the Social, Behavioral, and Economic Sciences and in Education and Human Resources (BCC-SBE/EHR) solicitation was released, and a set of awards were funded with a focus on community involvement in the design of the infrastructure. In FY 2015, a new solicitation, Resource Implementations for Data Intensive Research in the Social Behavioral and Economic Sciences (RIDIR), was issued for user-friendly large-scale next-generation data resources and relevant analytic techniques to advance fundamental research in SBE areas of study. Successful proposals will construct databases and/or relevant analytic techniques and produce a finished product to enable new types of data-intensive research in multiple disciplines or fields. The databases/techniques should have significant impacts across multiple fields by enabling new types of data-intensive research that includes, but is not necessarily limited to, the SBE sciences.

Also in FY 2014, ENG, in collaboration with the Air Force Office of Scientific Research (AFOSR), issued a DCL seeking EAGER proposals with the aim of transforming the ability to understand, manage, and control the operation of complex, multi-entity natural or engineered systems through innovative approaches that consider new dimensions in Big Data, Big Computing, and a symbiotic combination of Data and Computing. NSF and AFOSR supported highly innovative projects in their early stages that sought to address unique challenges and identify fruitful directions for analytics to transform engineering and scientific practice across various relevant disciplines and scales.

FY 2016 Request

- The DIBBs program will build on existing community development activities in and across the directorates and offices as well as the past three years of experiences in the program. As part of this, NSF directorates will expand the scale and scope of directorate and multi-directorate Data Science Pilots, reflecting maturity of the pilots initiated in previous years through co-investments with CISE/ACI. Based on individual directorates' investment priorities, expanded scope could include data reproducibility; interoperability of specific research data; sustainability plans; data policy and governance; security, privacy, data integrity and trustworthiness; exploration of innovative economic/operating models for archiving and curation; and learning and workforce development. Depending on scientific and engineering priorities, increased scale toward national-level and multi-agency activity will be explored.
- Foundational research efforts via the BIGDATA solicitation will be broadened to address not only scalability and the exploration of new data science capabilities, but also the interface between data sciences, multiple stakeholders, and sustainability, especially in use and long-term management of research data. This will complement both the development and deployment of new pilots and prototypes.
- CDS&E efforts will address issues associated with expanding both the base of researchers as well as the participation of new domains and disciplines. The availability of new tools and technologies resulting from research and infrastructure advances in computation and data will provide new opportunities for communities that have had limited access and use of research data and advanced computing infrastructure.
- Based on the results from the governance and cyberinfrastructure communities, EarthCube will develop programs that begin to bridge and support multiple communities. This will include integrating existing pilots and prototypes to address issues of scale and research support. In addition, EarthCube will focus on at-scale issues including development and deployment of common approaches and structures. This will include development of common tools, data systems, and virtual organizations to support the emerging geoscience communities and to coordinate regional and national cyberinfrastructure facilities.
- The SI^2 program will continue to expand its joint activities with DIBBs and related cyberinfrastructure, such as security and networking. As it continues to develop software sustainability models for scientific software, it will also begin to focus on common approaches and issues across multiple institutions and software projects including integration and coordination of development and deployment. This will include a focus on software infrastructure for major projects and awards, including Science and Technology Centers (STCs), Engineering Research Centers (ERCs), and Major Research Equipment and Facilities Construction (MREFC) projects.
- Through the NRT program, NSF will continue to support the training of STEM graduate students and the development of transformative and scalable models for STEM graduate education in computation- and data-enabled science and engineering.
- The EHR directorate will emphasize the development of communities of researchers and data scientists with the capacity to pursue graduate education research questions in technology-rich learning environments, and address complex issues of privacy and data sharing. This will occur through the EHR Core Research (ECR) program and other programs as appropriate.

- NSF will continue to support development of user-friendly, large-scale, next-generation data resources and relevant analytical techniques to advance fundamental SBE research through increased investment in the RIDIR program.

FY 2017

Foundational research within the CISE-led Big Data program will lead to use-inspired approaches, techniques, and paradigms for collecting, managing, and analyzing Big Data across all areas of science and engineering as well as enhancing analytical capabilities in health, government, policy, and other areas of national priority.

NSF support for Data Infrastructure for Research and Education through the DIBBs program will build on data and computational science foundational advances guided by research and education priorities within and across directorates. Individual research community considerations of accessibility, reproducibility, efficient sustainability, policy, confidentiality and privacy in addition to a range of scalability needs will result in a mature, extensible, flexible data ecosystem tailored to the nation's research priorities.

Today's science requires the highest levels of computational science and engineering and associated expertise. CDS&E will enable researchers to address the most challenging scientific problems of our time. It will help to create computational resources and a sustainable career path for computational and data scientists so that they become a permanent part of the scientific workforce.

EarthCube will produce an integrated framework of cyberinfrastructure for the open and easy discovery and access of geoscience data, software and services, information, and computational resources. It will also facilitate the coordination of geoscience data and software facilities to better serve the science requirements of the entire research community. The academic geoscience community will gain a stable venue to coordinate future infrastructure advances as science drivers and technologies change. Additionally, EarthCube will enable new transformative geoscience research and education. This will be achieved through the improved ability to access and analyze geoscience data, using effective software, models, and analytical tools that can simulate and examine complex and interrelated Earth processes.

SI^2 will lead to an increase in shared software for use across many scientific fields. It will also increase the incentive to develop such shared software without direct NSF support, which will make the concept of software as infrastructure sustainable, and this will result in increased and improved science and engineering research. SI^2 projects will continue to develop software for use by broad communities, with specific metrics based on the size of the user communities and their science and engineering research productivity. Those metrics support the goal of creating long-term, sustainable impact.

Prior CIF21 investments NRT investments will continue to support graduate students in computational- and data-enabled science and engineering, and to lead to the development and testing of potentially transformative and scalable models for graduate education more broadly. These investments will continue to facilitate broad training of computational- and data-enabled science and engineering graduate students, including the development of technical and professional skills that will prepare them for successful careers in various settings within or outside academe.

EHR will provide leadership in the use of institutional data, technology-based learning data, and issues of privacy for learning data with NSF and the community. EHR anticipates initiatives in FY 2017 that will involve large-scale use of education and learning data for the improvement of education at scale in the undergraduate and K-12 levels, and will conduct workshops in FY 2015 and 2016 in preparation for these activities.

The projects funded through the RIDIR solicitation are expected by FY 2017 to lead toward (1) new large-scale databases, substantial expansion or revision of extant databases, and/or the merging of extant databases that will enable data-intensive SBE research (i.e., research involving data resources that are well beyond the storage requirements, computational intensiveness or complexity that is currently typical in SBE areas of research); and/or (2) analytic tool(s) that would serve to enhance database use to address significant SBE research questions. RIDIR will enhance the ability to conduct data-intensive research that will address broad, important, fundamental SBE research questions.

Evaluation Framework

NSF has deployed tools to evaluate the scientific and educational impact and progress of the various CIF21 programs. The progress of the implementation of CIF21 was monitored and reviewed quarterly as part of a performance goal in FY 2014 and FY 2015. For more information about monitoring key program investments, see the FY 2014 Annual Performance Report in the Performance chapter.

The CIF21 Council will also consider a matrix of assessment methods and measures, incorporating input and guidance from the NSF ACCI. Planned evaluation activities will address each major CIF21 goal.

INNOVATIONS AT THE NEXUS OF FOOD, ENERGY, AND WATER SYSTEMS (INFEWS) $74,960,000

Overview

Growth of the global and U.S. population has placed an ever-increasing stress on three key and interconnected resources: food, energy, and water. There is a compelling and urgent need to understand, model, design, and manage the interconnected food-energy-water system, which incorporates natural, social, and human-built components. NSF can make important contributions by building the fundamental knowledge base; developing new ways to integrate heterogeneous data; analyzing, modeling, synthesizing, and controlling complex natural systems; expanding the workforce and piloting engineered solutions.

Of particular and timely interest are the production, resilience, safety, and security of food, energy, and water resources, and the systems in place to facilitate their generation, distribution, and consumption. Efficiency and conservation will be important goals to attain as stress on this interconnected system increases from population and economic growth, changes in land use practices, and more frequent and large spatial and temporal variations in precipitation, temperatures, and key environmental variables tied to environmental change. Developing countries are under extreme pressure as they endeavor to manage the multiple stressors of poverty, resource competition, agricultural disease, and rising food costs. There are important security implications of increasing stress on this interconnected food-energy-water system.[1] Recent droughts in California and corresponding impacts on the water, agricultural (food), and energy sectors are timely examples that illustrate these concerns.

Food, energy, and water systems interact in several ways. Water is required for energy-related processes such as hydropower, cooling of electric power plants, and fuel production. Energy is needed for wastewater treatment, desalination, pumping groundwater, and for transport of water and foodstuffs. Water and energy are critical for agriculture and food production. Biofuel production consumes water and, in some instances, can result in food shortages. In addition, different land use practices, increased urbanization, and weather variability have major impacts on water, energy, and agriculture resources. These multifaceted interactions are impacted on the one hand by fundamental laws governing various physical, chemical, and biological processes, and on the other hand by social, behavioral, and economic contexts and decisions made by individuals, organizations, and institutions.

Total Funding for INFEWS

(Dollars in Millions)

FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
-	-	**$74.96**

Goals

NSF's investment in "Innovations at the Nexus of Food, Energy, and Water Systems" (INFEWS) will:

- Support integrated experimental research towards creating a comprehensive food-energy-water socio-technical systems model;
- Advance knowledge/technologies that foster safer, more secure, and more efficient use of resources within the food-energy-water nexus, and;
- Support an integrated approach to build the next-generation INFEWS workforce.

[1] Quadrennial Defense Review 2014 (www.defense.gov/pubs/2014_Quadrennial_Defense_Review.pdf)

An interdisciplinary research effort on food-energy-water systems, including safety and security of these systems, presents a unique opportunity for NSF to work, within both a national and an international context, toward building a platform for more accurate, process-based models that incorporate relevant social, political, economic, and cultural factors, in addition to improved precipitation forecasts that have the capacity to presage tipping points in water availability and physical measurements that give real-time feedback on the effect of land, energy, and water management.

Approach

NSF is heavily invested in discovery research at a disciplinary level, as well as cross-cutting programs such as Water, Sustainability and Climate (WSC); Sustainable Chemistry, Engineering and Materials (SusChEM); Cyber Innovation for Sustainability Science and Engineering (CyberSEES); Hazards and Disasters (Hazards SEES); Basic Research to Enable Agricultural Development (BREAD); Critical Resilient Interdependent Infrastructure Systems and Processes (CRISP); and the Dynamics of Coupled Natural and Human Systems (CNH). INFEWS offers a significant opportunity for NSF to build on these investments and experiences in order to create new and effective research programs to advance the food-energy-water system knowledge base. NSF has initiated, and proposes to continue, the following leadership and governance structure for INFEWS:

- A senior leadership committee composed of assistant directors/office heads to provide long-term planning and overall guidance;
- Working groups of division directors and program officers, each overseen by assistant directors/office heads/division directors who are most relevant to the specific activity, to manage programs or activities and to coordinate among activities; and
- Interagency working groups to coordinate interagency activities and joint solicitations, as well as arrangements for engagement and collaboration with international partners.

NSF will build on ongoing internal partnerships among participating directorates to engage in collaborative multi-year activities involving two (or more) directorates. Management agreements will define directorate-planned contributions, remaining flexible on the requirement for participation; this flexibility will allow for partnerships with other agencies and international entities. NSF's approach and planned activities will be coordinated with other agencies through the National Science and Technology Council's Committee on Environment, Natural Resources, and Sustainability (CENRS).

The implementation proposed for INFEWS will include a combination of solicitations and Dear Colleague Letters (DCLs). Support mechanisms such as workshops and networks will be employed to engage the community in defining and refining research priorities and Early-concept Grants for Exploratory Research (EAGER) will test potential new approaches. There is need for flexibility since there are a multitude of intersections and interactions in the full food-energy-water interconnected system. For example, NSF may focus efforts on water-food and water-energy sub-systems as well as infrastructure vulnerabilities, smart technologies and decision tools, sustained cyberinfrastructure, and social and behavioral contexts and constraints. Thus, the food-energy-water system creates an overarching research umbrella that can accommodate the full system, while subsystems can be studied at other levels with differing or fewer partners. In future years, there may emerge one or more flagship programs that aim for full system modeling and integration and optimization.

Given extant partnerships and community interest, solicitations will be issued for the first awards to be made in FY 2016. INFEWS is planned to run from 2016 – 2021, and periodic reviews and assessments will be used to determine the life-span of particular investments and activities under the INFEWS umbrella. As the investment area evolves, decisions will be made regarding changes in emphasis areas, the need to assimilate INFEWS efforts into core programs, and timing for sunsetting of specific investments.

Investment Framework

INFEWS Funding by Directorate

(Dollars in Millions)

Dir/Office	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
BIO	-	-	$7.50
CISE	-	-	13.50
EHR	-	-	6.00
ENG	-	-	13.00
GEO	-	-	14.78
MPS	-	-	8.90
OISE	-	-	1.28
SBE	-	-	5.00
IA	-	-	5.00
Total, INFEWS	**-**	**-**	**$74.96**

Totals may not add due to rounding.

FY 2014 – FY 2015

INFEWS represents a natural segue from many NSF programs, including those under the SEES investment area. As such, INFEWS planning and development activities began in FY 2014 and will continue throughout FY 2015. NSF senior management is planning for the new investment area as community interest grows and is expressed in workshops and reports in a variety of disciplines. NSF senior management discussions with other federal agencies about common research interests and professional workforce needs will continue. NSF will support and organize regional workshops to promote interdisciplinary collaborative approaches to food-energy-water challenges. In FY 2015, NSF will continue with planning meetings and workgroup formation to develop solicitations and other funding mechanisms.

NSF will employ the DCL mechanism for INFEWS to support the wide variety of disciplines and interest in this broad investment area. FY 2015 workshops – including scientists from Department of Energy (DOE), U.S. Department of Agriculture (USDA), U.S. Geological Survey (USGS), and other agencies – will help inform DCLs. An NSF working group will be formed to define two to three specific topics for emphasis, such as critical research problems in the water-food or the water-energy subsystem, that are ready to be explored.

FY 2016 Request

In FY 2016, NSF will issue a multi-directorate INFEWS solicitation to support integrated research towards creating a comprehensive food-energy-water socio-technical systems model; to advance knowledge/technologies that foster more efficient, safe, and secure use of resources within the food-energy-water nexus; and to support an integrated approach to build the next-generation INFEWS workforce.

NSF will also issue one or more DCLs to include: consideration of how the food-energy-water system is embedded in social, political, economic, and cultural contexts; innovation in the safety and protection of food, energy, and water resources, and the systems in place to facilitate their generation, distribution, and/or consumption; computational capacity and cyberinfrastructure needs for analysis of large-scale data, including modeling and simulation; and integration of research with education and training of the next generation workforce.

The food-energy-water theme may be emphasized in NSF-wide programs, such as Research Experiences for Undergraduates (REU), Dynamics of Coupled Natural and Human Systems (CNH), Macrosystems biology, and those related to data science (e.g., BIGDATA and Data Infrastructure Building Blocks (DIBBs)). In FY 2016, INFEWS will also be one of the priority research theme areas for the NSF Research Traineeship (NRT) program as part of an effort to create innovative graduate education efforts in areas of national need. In addition, NEON (National Ecological Observatory Network) will continue to phase into operations, including full implementation of the stream ecology experiment (STREON) with the potential for broad impact on this NSF-wide investment.

FY 2017 – FY 2021

In FY 2017 – 2021, NSF will continue to make awards under the INFEWS solicitation and related DCLs. NSF expects to enhance interagency and international partnerships and to foster cross-disciplinary knowledge-sharing and networking through awards, meetings, workshops, and other activities.

Evaluation Framework

The progress of the implementation of this investment will be monitored and reviewed quarterly to ensure that it is on track as part of a FY 2016 performance goal. For more information about monitoring key program investments, see the FY 2016 Annual Performance Plan in the Performance chapter. All specific investments under INFEWS will be subject to rigorous peer review using NSF's merit review processes, and under the review of cross-NSF teams from staff level to program and division director-level to an agency senior management steering committee. NSF will use lessons learned from large, cross-NSF investment areas (e.g., SEES, I-Corps™) to inform evaluation planning and design for INFEWS. Planned evaluation activities include:

- Consulting internally and externally regarding evaluation strategy and methodology;
- Characterizing the initial portfolio, using new NSF portfolio management tools;
- Developing evaluation research questions;
- Analyzing NSF project reports for indications of advancement/growth of research; and
- Collecting and analyzing workforce development metrics.

Planning for evaluation is being initiated. Contract support will be engaged as soon as practicable to ensure objectivity of evaluation design and implementation, and the collection of relevant baseline data across the entire food-energy-water system.

NSF INNOVATION CORPS (I-CORPS™) $30,000,000
+$3,770,000 / 14.4%

Overview

Over the last few decades, the National Science Foundation (NSF) has been continuously seeking to further develop and nurture a national innovation ecosystem that builds upon fundamental research to accelerate the output of scientific research toward the development of technologies, products, and processes that benefit society. In FY 2011, NSF established the Innovation Corps (I-Corps™) program to meet such a purpose. I-Corps™ connects NSF-funded science and engineering research with the technological, entrepreneurial, and business communities, and fosters a national innovation ecosystem that links scientific discovery with technology development, societal needs, and economic opportunities. The I-Corps™ program provides immersive, experiential entrepreneurial education to scientists and engineers by supporting I-Corps™ Teams. The program builds a National Innovation Network (NIN) through I-Corps™ Nodes that are designed to provide learning environments for I-Corps™ Teams, and support regional needs for innovation education, infrastructure, and research. More recently, NSF has also awarded multiple I-Corps™ Sites, which help those institutions with existing entrepreneurial activities to spawn additional Teams.

The I-Corps™ program supports NSF's strategic goal to "Stimulate Innovation and Address Societal Needs through Research and Education." Specifically, I-Corps™ contributes directly to the strategic objective, "Strengthen the links between fundamental research and societal needs through investments and partnerships." Lab-to-Market, one of the Administration's Cross-Agency Priority (CAP) Goals, emphasizes the development of human capital with expertise and experience to accelerate technology commercialization through experiential entrepreneurial education such as I-Corps™.

Total Funding for I-Corps™
(Dollars in Millions)

FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
$20.49	**$26.23**	**$30.00**

Goal

The goals of the I-Corps™ program are:

- to capitalize NSF's investment in fundamental research;
- to offer academic researchers and students opportunities to learn first-hand about technological innovation and entrepreneurship, and thereby potentially realize the promises of their discoveries; and
- to prepare students for real-world experience through curricular enhancements, and provide them with opportunities to learn about and participate in the process of transforming scientific and engineering discoveries to meet societal needs.

Approach

The purpose of NSF I-Corps™ is to support NSF-funded researchers who, with teams, are interested in transitioning their research out of the lab. I-Corps™ awards are based on the maturity of the effort (i.e., whether the research is ready to leave the lab), strength of the team, and anticipated market value. The teams selected for I-Corps™ awards will receive additional support – in the form of mentoring and funding – to accelerate innovation that can attract subsequent third-party funding.

The I-Corps™ program comprises three components: I-Corps™ Teams, Nodes, and Sites.

An I-Corps™ Team comprises a principal investigator, an entrepreneurial lead, and an innovation/entrepreneurial mentor. An I-Corps™ Team award provides the project team access to resources to help determine the readiness to commercialize technology developed by previously- or currently-funded NSF projects. The outcome of the I-Corps™ Team awards is threefold: 1) a clear go/no-go decision based on an assessment of the market viability of proposed products and services; 2) should the decision be to move the effort forward, a transition plan to do so; and 3) a technology demonstration for potential partners.

I-Corps™ curricula include a strong educational component focusing on a hypothesis-driven approach to developing a methodology for evaluating both the technical merits and the market viability of the concept being proposed. The I-Corps™ program delivers the immersive curricula through I-Corps™ Nodes, wherein the curricula are developed and provided by the universities involved in these nodes. The experience to date indicated the Nodes provide not only an immersive learning environment but also significant "value added" to I-Corps™ Teams. NSF currently provides each I-Corps™ Node $350,000 to $1.25 million per year for up to three years, depending upon the number of institutions involved.

Recognizing some universities have existing institutional infrastructure and mechanisms to support entrepreneurship within their campuses, NSF established the I-Corps™ Sites program in order to contribute to a national innovation ecosystem. Sites are funded at academic institutions that already have existing innovation or entrepreneurial units, enabling them to nurture students and/or faculty who are engaged in projects having the potential to be transitioned into the marketplace. I-Corps™ Sites provide infrastructure, advice, resources, networking opportunities, training, and modest funding to enable groups to transition their work into the marketplace or to become I-Corps™ Team applicants.

I-Corps™ is managed within NSF by a core group of cognizant program officers comprised of representatives from all directorates and offices. The lead program officer is from the Directorate for Engineering, and co-lead program officers are from the Directorate for Computer and Information Science and Engineering (CISE) and the Directorate for Education and Human Resources (EHR). In addition to working closely with subject-matter experts within the directorates and offices, the lead program officers and the core group regularly meet with other federal agency representatives who are interested in implementing I-Corps™ within their own agencies.

Investment Framework

I-Corps™ Funding by Directorate

(Dollars in Millions)

Directorate/Office	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
BIO	$0.95	$1.00	$1.00
CISE	8.15	11.00	11.65
EHR	0.35	0.35	1.55
ENG	8.17	11.00	13.00
GEO	1.09	1.38	0.60
MPS	1.42	1.00	1.70
SBE	0.35	0.50	0.50
Total	**$20.49**	**$26.23**	**$30.00**

Totals may not add due to rounding.

FY 2014 – FY 2015

The I-Corps™ program is a key element in a series of NSF-supported programs concentrating on the innovation ecosystem. I-Corps™ has its genesis in a number of long-standing programs within NSF that support the innovation ecosystem, such as Engineering Research Centers (ERC), Industry/University Cooperative Research Centers Program (I/UCRC), Partnerships for Innovation (PFI), Science and Technology Centers (STC), Grant Opportunities for Academic Liaison with Industry (GOALI), Centers for Chemical Innovation (CCI), and Materials Research Science and Engineering Centers (MRSEC).

In FY 2014, the I-Corps™ program supported 139 NSF and three U.S. Department of Energy (DOE)/Advanced Research Projects Agency-Energy (ARPA-E) Teams, at $50,000 each, for up to six months. In FY 2015, about 190 NSF Teams will be supported. Additionally, NSF has collaborated with multiple federal agencies to expand the I-Corps™ program and its impact. NSF and ARPA-E signed a Memorandum of Understanding (MOU) in FY 2013 for collaboration that continued in FY 2014. In FY 2014, the National Institutes of Health (NIH) and NSF announced a collaboration to offer I-Corps™ curriculum geared towards the life sciences for NIH SBIR grantees in FY 2015. Additionally, NSF signed MOUs with the U.S Department of Homeland Security (DHS) and the DOE Office of Energy Efficiency and Renewable Energy (EERE) in FY 2015 for collaboration through I-Corps™.

Today, a hypothesis-driven approach to evaluating technical and market viability is offered to all I-Corps™ Teams through I-Corps™ Nodes. In FY 2011 and 2012, two I-Corps™ Nodes were awarded. In FY 2013, NSF awarded another three Nodes. In FY 2014, NSF awarded two additional Nodes, bringing the total number of I-Corps™ Nodes to seven.

NSF also established the I-Corps™ Sites at academic institutions that already have existing innovation or entrepreneurial units, enabling them to nurture students and/or faculty who are engaged in projects having the potential to be transitioned into the marketplace. The Site award size is up to $100,000 per year for three years. In FY 2013, four I-Corps™ Sites were funded. In FY 2014, NSF awarded 11 additional Sites, bringing the total number of active Sites to 15. NSF plans to support up to 20 active Sites in total in FY 2015.

I-Corps™ connects the academic research community with experts in innovation and entrepreneurship, who can help mentor budding entrepreneurs and evaluate the commercial viability of their ideas. Through I-Corps™ Sites and Nodes, the program is tapping into existing entrepreneurial support within many universities and is spawning regional innovation centers. With the portfolio of I-Corps™ Teams, Sites, and Nodes, NSF is helping to build a national innovation ecosystem. Overall, the program has been very well received by student entrepreneurs wishing to start small businesses, has increased faculty awareness of potential connections between fundamental research and innovation that is positively impacting their own research and educational practices, and has raised the level of interest in NSF-supported research from private investors.

Garnering of resources and support from multiple stakeholders is essential to the ultimate goal of making I-Corps™ education available to all research teams that can benefit from it. In FY 2015, the program structure will be re-evaluated and possibly modified with the goal to more actively involve the regional/local innovation communities, stimulate even more dynamic engagement between Nodes and Teams, and set course for the long-term sustainability of I-Corps™ Nodes.

FY 2016 Request

In FY 2016, NSF will support up to 220 I-Corps™ Teams and expects to maintain a steady state of seven Nodes and up to 20 active I-Corps™ Sites moving forward. NSF envisions potential partnerships with states that lead to the expansion of the I-Corps™ model across the Nation. NSF also plans to invest approximately $1.0 million on I-Corps™ Evaluation & Assessment activities.

FY 2017 – FY 2018

The I-Corps™ program is anticipated to be an integral part of the investment portfolio of the NSF going forward.

Evaluation Framework

I-Corps™ was the platform for one of NSF's three priority goals for FY 2013 - 2014. Progress towards priority goals was assessed quarterly by NSF senior management and was reported on the website of Performance.gov. The priority goal was to increase the number of entrepreneurs emerging from universities. Specifically, the priority goal states that by September 30, 2013, 80 percent of the Teams participating in the I-Corps™ program will have tested the commercial viability of their products or services. The I-Corps™ program exceeded that goal. The FY 2014 Strategic Review of NSF strategic objective − "Strengthen the links between fundamental research and societal needs through investments and partnerships" − also included data on I-Corps™ in its analysis.

Since the I-Corps™ program impact is long-term, it may take more than a one-year cycle to see substantive changes in these measures, and for this reason, quantifiable measures of short-term progress need to be used. I-Corps™ Teams act as a catalyst to commercialize NSF's investments in basic research, by accelerating the translation of their discoveries from the lab to market. Therefore, successful completion of the I-Corps™ Team grant would be expected to result in one or more of the following:

- New start-up businesses;
- Licensing;
- SBIR/STTR applications;
- A business plan suitable for review by private investors;
- Students prepared to be entrepreneurially competitive; and
- New curriculum development or improvement focusing on entrepreneurship and innovation.

In FY 2014, NSF's Evaluation and Assessment Capability office commissioned a study of the feasibility of conducting rigorous impact evaluation of I-Corps™ Teams. The study, which concluded in October 2014, aimed at exploring methodological options for rigorous impact evaluation of the program. Beyond the data that is now collected for I-Corps™, this study discusses areas in which additional data could be collected. These data would be essential in identifying suitable comparison groups necessary for a quasi-experimental design. Additional outcome and output data to be collected from teams on a longitudinal basis was also identified. Meanwhile, the National College Inventors and Innovators Alliance (NCIIA) will initiate additional longitudinal data collection efforts informed by this study and the program logic model. In FY 2015, an evaluation study of the I-Corps™ Teams program will be initiated and coordinated by NSF's Evaluation and Assessment Capability office with the data available at the time. The results of this evaluation are expected to inform future evaluations of the program, including Teams, Sites, and Nodes, which will likely be planned for FY 2017 and beyond.

RISK AND RESILIENCE

$58,000,000
+$38,000,000 / 190.0%

Overview

The economic competiveness and societal well-being of the United States depend on the affordability, availability, quality, and reliability of the infrastructure services provided. These infrastructure services include transportation (road, rail, and air), energy (electricity, gas, oil, and renewable), water, communications and networks (wireless and wired, including the internet), banking and finance, and many other components. The increased penetration and use of modern technologies has improved our Nation's productivity and quality of life. This penetration is now becoming deeply embedded into our society via wireless and wired networks, smart phones and other mobile devices, embedded systems, sensors, and social networks. As a result, the availability of real-time information about the state of these complex cyber-physical infrastructure systems is truly unprecedented.

Our increasing dependence on infrastructure services has increased the impact of risks that may cause these systems to fail. Risk severity can be understood as the product of the probability of an event and the magnitude of the event's consequences. These risks arise from at least two distinct sources: (a) extreme natural events such as tornadoes, space weather, hurricanes, storms, and earthquakes, and (b) man-made events such as malicious attacks and mechanical and technological failures. Some predict that extreme weather events and civil unrest will increase in frequency and severity.

It is essential that we work toward improving predictability and risk assessment and increasing resilience in order to reduce the impact of extreme events on our life, society, and economy. NSF is uniquely positioned to support such improvements that require multidisciplinary expertise in science, engineering, and education. NSF is focused on fundamental science and engineering issues such as understanding the dynamical processes that produce extreme events, how people respond to extreme events, and how to engineer resilient infrastructure. This improved knowledge will lead to better prediction, improved warning systems, and reduced disruption that will support the missions of other agencies such as the National Oceanic and Atmospheric Administration (NOAA), Department of Homeland Security (DHS), and the U.S. Geological Survey (USGS). Accordingly, this initiative is seen as complementary, rather than duplicative, to the interests of other agencies. Partnerships with mission agencies are critical to NSF's ability to meet its goal of enabling research results that can be translated into applications that provide societal benefits.

Total Funding for Risk and Resilience

(Dollars in Millions)

FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
-	**$20.00**	**$58.00**

Goals

NSF's goals through this investment are to advance knowledge of risk assessment and predictability and to support the creation of tools and technologies for increased resilience. These will be accomplished via support for: (1) improvements in our ability to understand, model, and predict extreme events and (2) creation of novel engineered systems solutions for resilient infrastructures, particularly those that leverage the growing infusion of cyber-physical-social components into the infrastructures.

Approach

NSF plans to use the following leadership and governance structure for the Risk and Resilience investment:

- A senior leadership committee composed of assistant directors/office heads to provide long-term strategy and overall guidance;
- Working groups comprised of program officers, each overseen by assistant directors/office heads/division directors who are most relevant to the specific activity, to coordinate programs or activities; and
- Interagency working groups to coordinate interagency activities as well as arrangements for engagement and collaboration with international partners if needed.

NSF will build on ongoing internal partnerships to engage in collaborative multi-year activities involving two (or more) directorates. Funding mechanisms for Risk and Resilience will include a combination of solicitations, co-funding with existing programs, Dear Colleague Letters (DCLs), workshops, and Research Coordination Networks (RCNs) to engage the community in defining research priorities and conducting research to meet the goals for the investment area.

The Risk and Resilience investment area represents a continuation and evolution of existing research investment areas. Some of these programs, such as Hazards SEES (Interdisciplinary Research in Hazards and Disasters), have concluded or will conclude in the near future, freeing up staff resources to participate in endeavors related to Risk and Resilience. Advanced planning for timing/staggering and management of solicitations and other activities will allow for a reasonable workload for involved staff and managers.

NSF supports basic research in the scientific and engineering disciplines necessary to understand disasters and extreme natural events. An enhanced NSF investment in this arena would result in a comprehensive and integrated risk and resilience knowledge base useful for informed decision-making and risk mitigation. An interdisciplinary research effort on risk and resilience systems presents a unique opportunity for NSF to work, within both a national and an international context, toward building a platform for more accurate models and improved predictive capabilities that incorporate relevant social, political, economic, and cultural factors. International partners have considerable expertise and information to offer U.S. researchers in mutually synergistic ways. For example, the Computer and Information Science and Engineering (CISE) joint program with the Japan Science and Technology Agency (JST) on Big Data for Disaster Research creates synergies between U.S. and Japanese researchers focused on improving the resilience and responsiveness of emerging computer systems and networks. NSF has longstanding international collaborations in earthquake programs. Advances will be accelerated by similar partnerships with other countries.

Investment Framework

Risk and Resilience Funding by Directorate
(Dollars in Millions)

Directorate	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
CISE	-	$6.00	$8.00
ENG	-	12.00	17.00
GEO	-	-	23.50
MPS	-	-	1.00
SBE	-	2.00	8.50
Total	**-**	**$20.00**	**$58.00**

Totals may not add due to rounding.

FY 2014 – FY 2015

In FY 2014, NSF conducted various planning activities including meetings, presentations, and workgroup formation to identify research areas in Risk and Resilience that NSF is uniquely positioned to support. A pilot competition, titled Resilient Interdependent Infrastructure Processes and Systems (RIPS), jointly supported by the Engineering (ENG), CISE, and Social, Behavioral, and Economic Sciences (SBE) directorates resulted in submission of 81 projects (156 proposals) that covered a wide range of infrastructures and cyber systems, and ten projects were supported.

In FY 2015, building on RIPS, NSF announced a solicitation in Critical Resilient Interdependent Infrastructure Systems and Processes (CRISP). The CRISP program aims to: (1) foster an interdisciplinary research community of engineers, computer and computational scientists, and social and behavioral scientists that will create new approaches and engineering solutions for the design and operation of infrastructure processes and services; (2) enhance the understanding and design of Interdependent Critical Infrastructure systems (ICIs) and processes that provide essential goods and services despite disruptions and failures from any cause--natural, technological, or malicious; (3) create the knowledge for innovation in ICIs so that they safely, securely, and effectively expand the range of goods and services they enable; and (4) improve the effectiveness and efficiency with which ICIs deliver existing goods and services.

In FY 2015, NSF will issue a DCL to announce the upcoming Prediction of and Resilience against Extreme EVENTS (PREEVENTS) program, describing general goals and anticipated funding levels.

FY 2016 Request

In FY 2016, NSF will build on strong foundations of core science and engineering programs in CISE, ENG, the Directorate for Geosciences (GEO), the Directorate for Mathematical and Physical Sciences (MPS), and SBE. In addition, this initiative builds on previous or ongoing programs such as Hazards SEES, Natural Hazards Engineering Research Infrastructure and Research (NHERI), and Cyber-Physical Systems (CPS).

In FY 2016, NSF will continue the CRISP and PREEVENTS research programs, which will advance our knowledge base and educate the next generation of scientists and engineers for increasing the resilience of our infrastructures in the face of changing and increasing risks.

CRISP

Our increasing dependence on infrastructure services has increased the impact of risks that may cause these systems to fail. Furthermore, the impact of deterioration of critical infrastructures becomes amplified since these infrastructures depend on each other for their function. For example, the electrical power system depends on the delivery of fuels for generating stations through transportation services, the production of those fuels depends on the use of electrical power, those fuels are needed by the transportation services, and all of these systems are intertwined with human decision making. The disruption of electrical power impacts water, emergency services, finance, and government services, among others. All of these services in turn depend on communication and control services provided by cyber-physical infrastructure – including computing, networking, data, and control services provided by complex, multi-scale interdependent systems and software – and cannot function without electricity. This complex set of interdependencies between the components of an interconnected set of critical infrastructures presents significant challenges to conceptualize, understand, model, design, and manage ICIs.

In FY 2016, NSF will continue to support the CRISP program by catalyzing collaborations among researchers across the domains of engineering, computer and computational science, and the social/behavioral/economic sciences to create theoretical frameworks and multi-disciplinary models of ICIs. The CRISP program will deepen fundamental knowledge and stimulate innovations to improve resilience, interoperations, performance, and readiness in ICIs, and to understand organizational, social, psychological, spatial, legal, political, and economic obstacles to improving ICIs, and to identify strategies for overcoming these obstacles.

PREEVENTS

Natural disasters cause thousands of deaths annually, and, in 2013 alone, they caused over $130 billion in damage worldwide.[1] It is estimated that recovery from Hurricane Sandy will cost over $65 billion, and that the drought of 2012 cost the U.S. economy over $30 billion. A focused research effort, PREEVENTS, will help us to better understand and mitigate the risks posed to the U.S. by natural hazards. PREEVENTS will deepen fundamental scientific understanding of natural processes underlying geohazards and extreme events, and will enable improved quantitative models and qualitative research that can enhance societal preparedness and resilience against such events. PREEVENTS will focus on natural hazards and extreme events, and will include the potential for disciplinary and multidisciplinary projects at all scales, especially areas ready for significant near- or medium-term advances.

PREEVENTS is the logical successor to the Hazards SEES program, but with a more GEO-focused perspective. PREEVENTS is designed to (1) enhance understanding of the fundamental processes underlying geohazards and extreme events on various spatial and temporal scales, as well as the variability inherent in such hazards and events; (2) improve models of geohazards, extreme events, and their impacts on natural, social, and economic systems; and (3) develop new tools to enhance societal preparedness and resilience against such impacts. PREEVENTS will focus on natural hazards and extreme events, not purely technological or deliberately or accidentally caused events/processes.

In FY 2016, NSF will support a solicitation for workshops and RCNs, and issue a DCL for co-funding opportunities with existing GEO programs. PREEVENTS workshops will: foster community development in disciplinary areas that need additional support; foster cross-disciplinary communities for problems that need such an approach but are not yet well established; and gather information for use in future PREEVENTS solicitations. RCNs will be supported to advance program goals by supporting

[1] Munich Re (2014). Topics Geo. www.munichre.com/site/corporate/get/documents_E1043212252/mr/assetpool.shared/Documents/5_Touch/_Publications/302-08121_en.pdf

groups of investigators to share information and ideas; coordinate ongoing or planned research activities; foster synthesis and new collaborations; develop community standards; and in other ways advance science and education through communication and sharing of ideas across disciplinary, organizational, geographic and international boundaries.

FY 2017 – FY 2020

CRISP
In FY 2017-2020, NSF will continue to support the CRISP program to advance knowledge and discoveries in critical interdependent infrastructure systems and processes.

PREEVENTS
In FY 2017-2020 NSF will continue to support workshops and RCNs in order to foster synthesis of results developed through the program, and identify areas that need additional attention through future competitions/programs. In addition, NSF will issue a solicitation for PREEVENTS-related research in FY 2017 and FY 2019, with up to $15 million in funding available annually.

Evaluation Framework
Investments and activities under the Risk and Resilience umbrella will be subject to periodic reviews and assessments. All specific investments will be subject to rigorous peer review using NSF's merit review processes, and under the review of cross-NSF teams, from staff level to program and division director-level to an agency senior management steering committee. As the investment area evolves, decisions will be made regarding changes in emphasis areas, the need to assimilate Risk and Resilience efforts into core programs, and timing for sunsetting of specific investments.

NSF will use lessons learned from large, cross-NSF investment areas (e.g., SEES, I-Corps™) to inform evaluation planning and design for Risk and Resilience. It is anticipated that NSF will have centralized capacity to develop a statement of work for enlisting contractor support. Planned evaluation activities include:

- Consult internally and externally regarding evaluation strategy and methodology;
- Characterize the initial portfolio, using new NSF portfolio management tools;
- Develop evaluation research questions;
- Analyze NSF project reports for indications of advancement/growth of research; and
- Collect and analyze workforce development metrics.

SCIENCE, ENGINEERING, AND EDUCATION FOR SUSTAINABILITY (SEES) $80,500,000 -$58,500,000 / -42.1%

Overview

A sustainable world is one in which human needs are met equitably without harm to the environment and without sacrificing the ability of future generations to meet their needs. Meeting this formidable challenge requires an increase in understanding of the integrated system of society, the natural world, and the alterations humans bring to Earth. NSF's Science, Engineering, and Education for Sustainability (SEES) activities aim to address this need through support for interdisciplinary research and education activities that cross the boundaries of the physical sciences, natural sciences, engineering, mathematics, computational sciences, human behavior, the social and economic sciences, and educational sciences to develop new understandings, theories, models, and technologies.

Total Funding for SEES

(Dollars in Millions)

FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
$164.49	**$139.00**	**$80.50**

Goals

SEES activities span the entire range of scientific domains at NSF and have three overarching multi-year goals:

1) Support interdisciplinary research and education that can facilitate the move towards global sustainability;
2) Build linkages among existing projects and partners and add new participants in the sustainability research enterprise; and
3) Develop a workforce trained in the interdisciplinary scholarship needed to understand and address the complex issues of sustainability.

Approach

SEES is a multi-year effort to coordinate and grow research and education associated with the environment, energy, and sustainability. NSF's work under SEES is a blend of activities − formal solicitations and less formal announcements of interest (e.g., Dear Colleague Letters) − that span multiple scientific disciplines and require input and oversight from multiple NSF directorates. Research on complex environmental pathways is supported and emphasized across NSF and is supplemented by activities focused on sustainable materials and technologies. SEES activities also help to build up the cross-disciplinary workforce for sustainability research and education, and to engage students and the public on sustainability science and engineering and their social implications. NSF conducts this work in awareness of and in concert with other federal agencies and national and international stakeholder groups whose function and mission complement NSF's role to ensure that sustainability goals are carried forward.

SEES programs are rooted in long-term, ongoing, environmental, energy, and education research. The portfolio approach—as opposed to a large single program—facilitates coordination, monitoring, and impact across the major investment areas and also across NSF, as SEES activities are complex and highly interdisciplinary. The SEES organizational structure includes:

- A senior leadership committee composed of assistant directors/office heads to provide overall planning and guidance;

- A cross-agency SEES Implementation Group composed of division directors and lead program directors, who develop consistent guidelines, provide internal and external communication, and shape evaluation plans;
- Working groups of program directors, each overseen by assistant directors/office heads/division directors who are most relevant to the specific activity to manage programs or activities; and
- Interagency working groups and international partnerships to carry out transition planning as the initiative sunsets.

NSF leadership recognizes the need for cross-cutting investments and interdisciplinary teaming to take on the challenge of sustainability research. There is continued need to support research collaborations that develop new understanding, theories, models, and technologies, educate the future workforce, and inform the public.

Investment Framework

SEES Funding by Directorate

(Dollars in Millions)

Dir/Office	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
BIO	$31.00	$21.00	$17.50
CISE	13.92	11.00	-
ENG	13.20	12.00	3.00
GEO	68.00	59.00	34.00
MPS	25.36	22.50	16.00
SBE	3.01	3.50	-
OISE	10.00	10.00	10.00
Total	**$164.49**	**$139.00**	**$80.50**

Totals may not add due to rounding.

FY 2010 – FY 2013

NSF established the SEES investment area in FY 2010 in order to use a systems-based approach to understanding, predicting, and reacting to change in the linked natural, social, and built environment and to address challenges in environmental and energy research and education. The initial programs in FY 2010 were Dimensions of Biodiversity (DoB), Earth Systems Modeling (EaSM), Ocean Acidification (OA), and Water Sustainability and Climate (WSC). NSF has supported sustainability-related research and education for decades. The SEES portfolio builds on this foundation and draws programs that address sustainability into a common framework to optimize investments and outcomes.

FY 2014 – FY 2015

In FY 2014, NSF continued to support important scientific and societal contributions, and to make significant progress toward achieving programmatic goals. In FY 2015, SEES passes the mid-point of its planned lifetime and enters a transition period toward "sunsetting" in FY 2017, the last year in which funds will formally be associated with the SEES activity. The FY 2015 Estimate for SEES is $139.0 million. In FY 2015, NSF will continue investment in SEES programs initiated in FY 2010-2014, with the exception of Sustainable Energy Pathways (SEP), OA, SEES Fellows, and Research Coordination Network (RCN-) SEES track. SEES programs will continue to support important scientific and societal contributions during the phase-down period, and will make significant progress toward achieving programmatic goals through projects currently underway.

SEES competitions held, ongoing, or expected to run in FY 2014-2015 include: DoB, Earth Systems Modeling (EaSM), WSC, CyberSEES, Coastal SEES, Dynamics of Coupled Natural and Human Systems (CNH), Hazards and Disasters (Hazards SEES), Sustainable Chemistry, Engineering and Materials (SusChEM), Arctic SEES, and Food Systems. Of particular note is the Sustainability Research Networks (SRN) solicitation issued in FY 2014 that will build linkages to expedite progress in understanding the complicated landscape of urban sustainability, which has emerged as a critical need for the 21st century.

FY 2016 Request

Consistent with the planned "sunsetting", further reductions are planned for FY 2016 and FY 2017. The total request for SEES in FY 2016 is $80.50 million. Funding will support the following SEES programs: DoB, EaSM, SRN, Coastal SEES, Hazards SEES, SusChEM, and Partnerships for International Research and Education (PIRE) (ongoing sustainability-focused projects from FY 2012 competition).

Long-term planning will continue to stress consolidation and coordination of existing activities; networking and dissemination of information from the growing SEES knowledge base to the scientific community, policy-makers, and the public; and the workforce development critical for producing the next generation of sustainability scientists and engineers. The EaSM, Hazards SEES, and WSC programs will end, but important elements of these programs will form the basis of standing programs that will be piloted in the final years of the SEES investment area. Funding for research related to Food Systems will transition out of SEES and be folded into the new NSF-wide Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS) activity.

FY 2017

FY 2017 is the last year in which funding will be formally associated with the SEES portfolio. NSF staff and managers will be finalizing implementation of follow-on activities for other SEES programs and sustainability themes to ensure a well-informed transition. As there is keen interest and need for hazards-related research, currently, NSF senior management is planning for the Hazards and Water Sustainability and Climate programs to continue beyond 2017 and to be supported by at least three NSF directorates. SusChEM is anticipated to transition to an ongoing program among three NSF directorates. Other SEES programs with ongoing community interest that will be supported through NSF core programs include: ArcSEES, Coastal SEES, DoB, EaSM, OA, and CNH.

Certain SEES programs that were intended as short-term catalysts to boost community interest and capacity and complement other NSF programs will be discontinued, including SRN, PIRE (SEES-focused 5-year awards made in 2012), and Small Business Technology Transfer Program (STTR)-SEES. In the case of SRN, the program will conclude as SRN competitions have served the purpose of establishing community partnerships in emerging sustainability science and engineering areas.

Evaluation Framework

Significant thought has gone into how to define success under SEES, and monitoring and evaluation have been aspects of the SEES portfolio since its inception. NSF has received abundant internal and external feedback on the portfolio and its programs through trans-disciplinary workshops, Advisory Committee meetings, a National Academy conference, and various newsletters, articles, and publications. NSF will employ a variety of tools to evaluate the scientific impact and progress of the various programs in the SEES portfolio. In FY 2014, NSF issued a Request for Quotes and awarded a contract for evaluation of the SEES portfolio. Evaluation activities under the contract include:

- **Evaluation Design and Plan** − developing research questions and framework for analysis, including logic models, and developing data collection instruments and methodologies for those analyses (final plan delivered December 2014)

- **Historical Review** − understanding of sustainability related activities over time, how SEES fits into history, and to discern if the coordinated approach under SEES has brought about different outcomes in terms of increased productivity, scientific findings, and interest level (internally and externally) (draft delivered December 2014);

- **Comparative Analysis of SEES and non-SEES NSF programs** − to determine if activities conducted and programs developed under the SEES portfolio are achieving different outcomes compared to similar NSF programs, and if the SEES portfolio is filling a gap in the sustainability science, engineering, and education enterprise (draft sub-task delivered October 2014); and

- **Network Analysis** – development of collaboration indicators, influence of participation in SEES programs on individual researchers, and a comparison of networking activities of SEES and non-SEES individuals (planned for 2015/2016).

The progress of the implementation of this investment was monitored and reviewed quarterly as part of a performance goal in FY 2014 and FY 2015. For more information about monitoring key program investments, see the FY 2014 Annual Performance Report in the Performance chapter.

SECURE AND TRUSTWORTHY CYBERSPACE (SaTC) $124,250,000
+$1,500,000 / 1.2%

Overview

The Secure and Trustworthy Cyberspace (SaTC) investment is aimed at building a cybersecure society and providing a strong competitive edge in the Nation's ability to produce high-quality digital systems and a well-trained workforce. Achieving a trustworthy cyberspace is a critical challenge as corporations, agencies, national infrastructure, and individuals have been victims of cyberattacks, which exploit weaknesses in technical infrastructures as well as in human behavior. Through long-term foundational research in algorithms, models, probability theory, reliability, statistical theory and analysis, cryptanalysis, system structures, and secure computing, SaTC promises to develop the scientific foundations for cybersecurity and privacy research for years to come. SaTC funding broadens the cybersecurity research portfolio through support for multi-disciplinary projects with expertise in computer, computational, statistical, mathematical, social, behavioral, and economic sciences. Such projects, for example, investigate the motivations and incentives of individuals and institutions, both as attackers and defenders, and lead to a more cybersecure society. Additionally, SaTC supports new, innovative approaches to educate and prepare tomorrow's cybersecurity researchers and professionals with the skills and knowledge necessary to build a secure and trustworthy cyberspace.

Total Funding for SaTC

(Dollars in Millions)

FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
$126.00	**$122.75**	**$124.25**

Goal

The long-term goal of the SaTC program is to build a knowledge base in cybersecurity that enables discovery, learning, and innovation, and ultimately leads to a more secure and trustworthy cyberspace. The program aligns with the 2011 national cybersecurity strategy, *Trustworthy Cyberspace: Strategic Plan for the Federal Cybersecurity Research and Development Program*.[1] This plan details four subgoals that together cover a set of interrelated priorities for federal agencies that conduct or sponsor research and development in cybersecurity. These four subgoals are: (1) inducing change, (2) developing scientific foundations, (3) maximizing research impact, and (4) accelerating transition to practice. In order to achieve these subgoals, a coordinated, interdisciplinary program like SaTC is needed.

Approach

The Computer and Information Science and Engineering (CISE) directorate leads this NSF-wide effort, and is joined by the Education and Human Resources (EHR), Engineering (ENG), Mathematical and Physical Sciences (MPS), and Social, Behavioral, and Economic Sciences (SBE) directorates. Each of these organizations supports a research community whose abilities are needed collectively to build the envisioned secure and trustworthy cyber environment, and to prepare the scientists and supporting workforce needed to sustain and improve that environment. The SaTC program is managed by a Working Group (WG) comprised of program directors from the participating directorates.

EHR invests in the CyberCorps®: Scholarship for Service (SFS) program, which supports cybersecurity education and workforce development. SFS has funded more than 2,100 students and provides capacity-building grants to promote cybersecurity education and research at higher education institutions. SFS will

[1] www.whitehouse.gov/sites/default/files/microsites/ostp/fed_cybersecurity_rd_strategic_plan_2011.pdf

continue its focus on increasing the number of qualified students entering the fields of information assurance and cybersecurity, which enhances the capacity of the U.S. higher education enterprise to continue to produce professionals in these fields to secure the Nation's cyberinfrastructure.

NSF also collaborates with other federal partners on cybersecurity. For example, NSF co-chairs the Networking and Information Technology Research and Development Program (NITRD) Cyber Security and Information Assurance (CSIA) Senior Steering Group (SSG), which provides leadership across the government in cybersecurity R&D by serving as a forum for information sharing and cross-agency agenda setting. SaTC activities are also coordinated with other agencies through NSF's participation in the CSIA Interagency Working Group (IWG) and the Special Cyber Operations Research and Engineering (SCORE) Interagency Working Group. In addition, NSF and the Department of Education (ED) co-lead the Formal Education Component of the National Initiative for Cybersecurity Education (NICE).

The following paragraphs describe the specific objectives of NSF's SaTC program, and how they relate to the four thrusts of the Federal Cybersecurity Strategic Plan:

Inducing Change

- Focus the direction of research on four game-changing research topics – designed-in security, moving target defense, tailored trustworthy space, and cyber economic and behavioral incentives – to better understand the motivations, incentives, and behaviors of users, attackers, and defenders.
- Provide the foundations and tools for privacy, confidentiality, accountability, and anonymity, as well as extraction of knowledge from massive datasets without compromising societal values.
- Advance the design and implementation of software that exhibits resiliency in the face of an attack, the design and composition of software components into large-scale systems with known security properties, and the design of reliable systems including attention to behavior and human factors.

Developing Scientific Foundations

- Develop the scientific foundations for digital systems that can resist attacks, including a range of cryptographic algorithms and statistical tools that can withstand attacks from novel computing engines, such as quantum computers.
- Develop the mathematical and statistical theory and methodologies required to model and predict the behavior of large-scale, complex systems; assure that the large-scale computations in many fields of research are not vulnerable to manipulation or compromise; and develop and implement improved cybersecurity defenses for scientific environments and cyberinfrastructure.
- Develop the scientific foundations to understand how individuals, groups, organizations, and other actors make decisions in the realm of cybersecurity as well as market-based approaches to align incentives for investments, efficiently share risks, and internalize externalities.

Maximizing Research Impact

- Ensure that the Nation's populace understands the security and privacy characteristics and limitations of the digital systems on which they rely daily.
- Coordinate with the NSF Cyber-enabled Materials, Manufacturing, and Smart Systems (CEMMSS) investment to support foundational research in cybersecurity issues arising in advanced manufacturing, robotics, and critical infrastructure, such as Smart Grids.
- Investigate opportunities and challenges in organizational alliances around cybersecurity; and examine alternative governance mechanisms, for example, private-public partnerships and international agreements.

Accelerating Transition to Practice

- Provide insight and incentives into the process for innovation diffusion and adoption at the societal, organizational, group, and individual levels.
- Drive innovation through applied research, development, and experimental deployment and implementation, resulting in fielded capabilities and innovations of direct benefit to campus networks, systems and environments supporting NSF science and engineering research and education environments.
- Transition successful basic research results and commercial innovations into early adoption and use, allowing NSF cyberinfrastructure to serve as a premier proving ground and state-of-the-art environment for advancing cybersecurity solutions and moving them into technical and organizational practice.

In addition, SaTC addresses important issues in the education and preparation of tomorrow's cybersecurity researchers. Specific objectives are to:

- Promote innovation, development, and testing and evidence-gathering of new curricula and learning opportunities to create and sustain an unrivaled cybersecurity workforce, capable of developing sound and secure cyberinfrastructure components and systems.
- Study innovative approaches in cybersecurity training and education to understand their impact and provide a basis for continual refinement and improvement.

Investment Framework

SaTC Funding by Directorate

(Dollars in Millions)

Directorate/Office	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
Computer and Information Science and Engineering	$71.18	$70.00	$70.50
Education and Human Resources	44.87	45.00	45.00
Engineering	3.75	3.25	3.25
Mathematical and Physical Sciences	2.00	0.50	1.50
Social, Behavioral, and Economic Sciences	4.20	4.00	4.00
Total	**$126.00**	**$122.75**	**$124.25**

Totals may not add due to rounding.

FY 2014 – FY 2015

In FY 2014, CISE, EHR, ENG, MPS, and SBE jointly issued the SaTC solicitation to continue to elicit proposals that expand the research and development of a secure and trustworthy cyberspace. In FY 2015, the SaTC solicitation was reissued, and a new size category was created for projects – "Large" (up to $3.0 million in total budget and up to five years in duration). This new category aims to provide portfolio balance through investments in a diverse set of collaborations focused on large-scale Trustworthy Computing (TwC) research, large-scale Social, Behavioral, or Economic Sciences (SBE) research, or integrated TwC/SBE efforts.

To foster additional multidisciplinary research in privacy, NSF issued a Dear Colleague Letter (DCL) in FY 2014 encouraging the submission of proposals that specifically addressed the need to develop new and deeper fundamental understandings of privacy in today's networked world. In FY 2015, SaTC is continuing to fund projects on fundamental research in privacy.

Education and training continued to be a major component of SaTC in FY 2014 and FY 2015. EHR

continued to fund SFS capacity-building awards, which focus on recruiting and retaining underrepresented minorities, women, first-generation undergraduate students, low-income students, and/or veterans, as well as applications by and partnerships with minority-serving institutions and two-year colleges. Additionally, NSF sponsored a workshop in FY 2014 that brought together computer science educators and cybersecurity researchers to discuss more innovative approaches to advance cybersecurity education. On the basis of this workshop, in FY 2015 SaTC is focusing on new ways to promote innovation, development, and assessment of new learning opportunities in order to create and sustain an unrivaled cybersecurity workforce. NSF also supported, and is continuing to support, large-scale cybersecurity competitions through collaborations with California State Polytechnic University Pomona's National Cybersecurity Sports Federation, which provides a shared pathway for students to learn cyber competitions the way athletes learn a sport.

Broadening the SaTC research community is critical to facilitating advances in cybersecurity research. Building on the successes of a workshop in FY 2013, a second workshop for aspiring SaTC principal investigators (PIs) was held in FY 2014. The goal was to educate potential SaTC researchers on the priorities of the program and components of successful research projects. NSF will continue to use this approach to bring new researchers with a broad set of talents and interests into the SaTC PI community.

Several workshops focused on cybersecurity research were held in FY 2014, including a Science of Cybersecurity workshop that considered specific foundational problems (e.g., metrics, fundamental results, evidence-based research, and protection of critical infrastructure); a "Cybersecurity 2025" workshop that sought to catalyze a community-wide discussion to review SaTC progress relative to the federal strategic plan and to envision long-term research agendas for the field; and two workshops at the NSF-funded Institute for Computational and Experimental Research in Mathematics (ICERM) to explore mathematical developments needed in cybersecurity research. Building on the results of the Science of Cybersecurity workshop, SaTC will fund projects that focus on the scientific foundations of cybersecurity in FY 2015. NSF is also holding a cross-agency workshop in FY 2015 to review progress made in developing a science of cybersecurity, and to propose ways in which needs and results can be communicated more effectively to stakeholders from academe, industry, and government.

In order to facilitate translation of research to practice, a session at the FY 2015 SaTC principal investigator (PI) meeting was dedicated to educating SaTC PIs about other NSF programs that focus on transition to practice, such as NSF Innovation Corps (I-Corps™) and the Accelerating Innovation Research (AIR) activity in the Partnerships for Innovation (PFI) program. Over 400 cybersecurity researchers and educators from academe, industry, and government attended the SaTC PI meeting.

In FY 2014, NSF announced two new partnerships with industry in the domain of cybersecurity. NSF issued a new solicitation in partnership with Intel in the area of cyber-physical systems security and privacy (CPS-Security). The goal of this partnership between NSF and Intel is to foster novel, transformative, multidisciplinary approaches that ensure the security of current and emerging cyber-physical systems. Projects are being awarded in FY 2015. NSF also issued a solicitation with the Semiconductor Research Corporation (SRC) in FY 2014 for Secure, Trustworthy, Assured and Resilient Semiconductors and Systems (STARSS). The STARSS solicitation resulted in nine projects jointly funded by NSF and SRC focused on strategies, techniques, and tools that avoid and mitigate vulnerabilities and lead to semiconductors and systems that are resistant and resilient to attack or tampering. In FY 2015, SaTC is continuing this partnership with SRC through a STARSS perspective in the SaTC solicitation.

In FY 2015, NSF partnered with the US-Israel Binational Science Foundation (BSF) to support collaborations between U.S. and Israeli researchers focused on foundational research in all areas of

cybersecurity. It is expected that this partnership will yield international teams that will enhance the security and trustworthiness of cyberspace in the long term.

FY 2016 Request

The following activities are planned:

- Continue to fund innovative projects in the science of cybersecurity, the science of privacy, cybersecurity for cloud computing, and cybersecurity for cyber-physical systems. Fund at least two projects on big data analytics for cybersecurity, and at least two projects on software engineering for cybersecurity.
- Issue a new solicitation based on community feedback and the results of a portfolio analysis, with a specific call for research into privacy, security of cyber-physical systems, and low-cost and/or low-effort approaches for securing systems such as web services and the Internet of Things (IoT).
- Hold a series of workshops with key stakeholders to identify research areas based on the recommendations in the NITRD National Privacy Research Strategy that is expected to be published in late FY 2015/early FY 2016. One of these workshops will be a cross-agency workshop that reviews progress toward developing a science of privacy, and that proposes ways that research needs and results can be better communicated across government, academe, and industry.
- Hold the next in a series of biennial PI meetings with representation from academe, industry, and government, including other federal agencies. This PI meeting will feature sessions on emerging frontiers in cybersecurity, including a session focused on the science of privacy. The PI meeting will also showcase successful Transition to Practice/I-Corps™/AIR activities resulting from SaTC investments. It will also serve as an opportunity for the CPS-Security performers to review progress and identify critical unaddressed problems and directions.
- Leverage the ongoing SaTC portfolio analysis to identify and develop new directions for FY 2016 and beyond.
- Support projects through a new Transition to Education (TtE) mechanism. Through TtE, research results in software engineering, science of cybersecurity, and designed in security will be moved into relevant course curriculum that will be implemented, assessed, and improved in a variety of settings. Such efforts will be supported using TtE supplements and options. TtE is analogous to the Transition to Practice (TTP) component of SaTC whereby research results that show promise beyond furthering basic research are transitioned into practical applications.
- Support research and development in cybersecurity education to encourage and test innovative approaches to the preparation of cybersecurity professionals in formal and informal learning settings. As part of this, support the development and assessment of learning modules and approaches for cybersecurity education that can be incorporated into computer science instruction, quantitative and scientific literacy curricula, and science and engineering programs for undergraduate and graduate students who will need basic understandings of cybersecurity relevant to their domains. Foundational research to examine the basic concepts and instructional approaches for cybersecurity also will be supported. These efforts will be included in such programs as the EHR Core Research (ECR) program, CyberCorps®: Scholarship for Service (SFS), Cyberlearning and Future Learning Technologies (Cyberlearning), and the NSF-wide Improving Undergraduate STEM Education (IUSE) program.

FY 2017 and Beyond

Building on the knowledge base developed during the previous years, SaTC will continue to focus on game-changing research and education, and the development of digital systems that are resistant to attacks. In coordination with the NSF-wide CEMMSS investment, SaTC will include a focus on secure advanced manufacturing systems, robotics, and critical infrastructure. SaTC will also focus on transitioning to practice research results ready for experimental deployment, early adoption, commercial innovation, or implementation in cyberinfrastructure. In addition, SaTC will build upon existing, and

develop new, partnerships with other federal agencies, industry, and international organizations to effectively achieve its long-term goals. The cybersecurity research community is also expected to grow to include more researchers who cross the boundaries between computer science, engineering, economics, social and behavioral sciences, statistics, and mathematics. A PI meeting will be held with interagency representation, focusing on the science of cybersecurity and novel interdisciplinary areas of research.

NSF will continue to promote the development of and related research about new curricula and learning opportunities to augment the cybersecurity workforce with focused efforts to recruit and retain underrepresented minorities, women, first-generation/low-income students, and/or veterans.

Evaluation Framework

NSF has engaged the Science and Technology Policy Institute (STPI) to conduct a program evaluation feasibility study for the SaTC program. This evaluation feasibility study is examining the baseline portfolio of SaTC investments and identifying metrics to measure progress towards goals as part of an impact assessment. The evaluation feasibility study was initiated in the fourth quarter of FY 2012, and a final report is anticipated in FY 2015.

This feasibility study has developed a plan for an impact assessment of the SaTC investment. The approach outlined below has been followed:

- Meetings have been held with the SaTC working group and SaTC management to examine the past and current portfolio of awards, including an assessment of the components of the portfolio by technical and scientific content. In addition, as part of this portfolio analysis, various recommendations from federal advisory boards and stakeholder communities on how to structure future cybersecurity investments have been synthesized.
- A logic model has been developed to help NSF track progress toward its major scientific objectives (e.g., discovery of the root causes of threats and attacks and continuous investment in transformational approaches that improve the security of cyberspace; and development of a systematic scientific approach to cybersecurity, including discovery of laws and principles).

Based on the results, NSF and a third-party contractor will develop the appropriate plan for assessing progress across NSF's SaTC activities, following the framework STPI is developing.

In addition, staff from the Office of the Director for National Intelligence (ODNI) were charged with monitoring the Comprehensive National Cybersecurity Initiative (CNCI) investments across agencies engaged in categorizing projects using the four game-changing research themes outlined in the national cybersecurity research and development strategy. The results of this activity will be reported to the CSIA SSG in FY 2015.

Research that has been transitioned into practice will be highlighted at the biennial PI meetings (e.g., new products, patents, start-ups, and commercialization of new approaches and techniques).

The Office of Personnel Management's Human Resources Solutions (HRS) conducted an evaluation of the SFS program, primarily focusing on the program's scholarship and capacity building tracks. HRS and NSF are finalizing a report on the 2012-2013 Summative Evaluation, and it is expected to be ready for public distribution by the end of FY 2015. Going forward, program monitoring and evaluation activities for the SFS program will be coordinated to reduce the burden on principal investigators, scholarship recipients, and program administrators. HRS will consult with NSF on the program evaluation in ways that maintain the integrity and independence of the evaluation while ensuring that the evaluation is sensitive to the program's objectives, goals, mission, vision, and any pending legislation or executive level initiatives. The intent of the SFS program monitoring system is to provide a description of the implementation and selected desired outcomes of the program over time and to address the issues raised

by the GAO report, *Cybersecurity Human Capital: Initiatives Need Better Planning and Coordination* (GAO-12-8; November 2011).[2]

[2] www.gao.gov/new.items/d128.pdf

UNDERSTANDING THE BRAIN (UtB) $143,930,000
+$37,490,000 / 35.2%

Overview

Understanding the Brain (UtB) is a multi-year effort that continues the previously titled "Cognitive Science and Neuroscience" activity and that includes NSF's participation in the Administration's Brain Research through Advancing Innovative Neurotechnologies (BRAIN) Initiative.

For over three decades, NSF has supported fundamental brain research from molecules to cognition and behavior, and enabled technology development, through many disciplinary programs spread across the Foundation. In 2012, Congress encouraged NSF to create a cross-foundation activity in Cognitive Science and Neuroscience, and also encouraged the White House to form an Interagency Working Group on Neuroscience (IWGN) under the National Science and Technology Council, which is co-chaired by NSF. In FY 2013, the President announced the multi-agency BRAIN Initiative, with NSF as one of the lead participating agencies. The Understanding the Brain activity draws together and consolidates NSF's ongoing activities in Cognitive Science and Neuroscience and the BRAIN Initiative. With UtB, NSF aims to leverage its existing investments and foster greater collaboration among these research and technology disciplines to accelerate fundamental discoveries in neuroscience, cognitive science, and neuroengineering.

Understanding the brain is one of the grand scientific challenges at the intersection of the physical, life, behavioral, and engineering sciences. The National Research Council report, "*Research at the Intersection of the Physical and Life Sciences*" (2010), identified "Understanding the Brain" as one of the top five grand challenges for research that will significantly benefit society. The National Academy of Engineering has also recognized "*Reverse-Engineering the Brain*" as a Grand Challenge for Engineering (2008).

Many incremental advances in research and technology in recent decades are elucidating individual elements of the nervous system and brain and their relationships to specific behaviors and cognitive processes. However, there remains much to discover to attain a comprehensive understanding of the general principles underlying how cognition and behavior relate to the brain's structural organization and dynamic activities, how the brain interacts with its environment, and how the brain can recover from lost functionality.

The critical challenge to this comprehensive understanding is to integrate research and innovation across multiple scales of space and time, from molecular, physical (e.g., biophysical and biochemical), physiological, and genetic to cognitive, behavioral, and social, with the ultimate goals of establishing integrative, quantitative, and predictive theories of brain structure and function.

To address this challenge, NSF is making major investments in collaborative fundamental science, in innovative enabling technologies, and in workforce development to accelerate discovery and revolutionize our understanding of the brain. NSF is leveraging and substantially expanding its investments in high-risk/high-reward exploratory and transformational scientific and engineering research with emphasis on integration across scales and disciplines. Novel experimentation, multimodal data integration, and theoretical developments that span the molecular, biophysical, biochemical, systems, genetic, organismal, and social scales will elucidate the mechanisms linking dynamic brain activity to behavior and physiology of the whole organism in its environmental context. New conceptual and physical tools with the associated technologies will expand the limits of detection, refine the level of experimental manipulation, and improve computational capability, allowing a fuller characterization and analysis of temporal and spatial patterns of the activity of networks of neurons that drive behavior. Other

investments will aim to improve education through discoveries in the neural bases of learning, and enhance our understanding of how the brain adapts to changing environments.

NSF is uniquely positioned to advance research on understanding the brain by bringing together a wide range of scientific and engineering disciplines to reveal the fundamental principles underlying brain structure and function. The co-mingling of these disciplinary and interdisciplinary fields is expected to yield enhanced understanding of the brain, cognition, and behavior, through the development of new technologies and theories. NSF has been a catalyst for transformative breakthroughs in brain research and related technologies; for example, the fundamental research that led to the development of optogenetics, the CLARITY transparent brain preservation technique, brain-machine interface systems, and the first FDA-approved artificial retina began with NSF support. In addition, NSF's capacity for enabling integrative activities in neuroscience at a global scale is exemplified by NSF's long-term supporting role in the International Neuroinformatics Coordinating Facility (INCF).

NSF's cross-foundation activity has brought the relevant but disparate scientific communities together, and has resulted in the funding of novel collaborative efforts and innovative research and technology awards. In FY 2013, NSF released a cross-foundation Dear Colleague Letter "Accelerating Integrative Research in Neuroscience and Cognitive Science (AIR-NCS)" and funded nine new Integrated NSF Support Promoting Interdisciplinary Research and Education (INSPIRE) awards and one new Research Coordination Network (RCN) as a result. In FY 2013 and FY 2014, NSF sponsored a series of workshops across the participating science and engineering directorates to provide input on research priorities and engage in preparatory collaborative activities. NSF used the resulting reports, white papers, and research articles to develop this multi-year roadmap of investment priorities and to devise targeted calls for research proposals. For example, in FY 2014 the Directorate for Biological Sciences (BIO) published a Dear Colleague Letter (DCL) for Early-concept Grant for Exploratory Research (EAGER) proposals for "catching circuits in action" projects to apply innovative neurotechnologies to study neural circuits responsible for cognition and behavior. This resulted in 36 highly interdisciplinary awards focused on elucidating the functional roles of neural circuits, funded by multiple NSF directorates. These awardees were invited to a joint meeting with the first cohort of NIH BRAIN Initiative awardees following the annual meeting of the Society for Neuroscience in Washington D.C. as part of the President's BRAIN Initiative.

Total Funding for UtB

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
Understanding the Brain (UtB)	**$92.62**	**$106.44**	**$143.93**
BRAIN Initiative	*22.62*	*48.48*	*71.56*

Goal

The overall goal of UtB is *to enable scientific understanding of the full complexity of the brain in action and in context*. This multi-year goal is being pursued across the four ongoing priority areas:

1. Develop innovative neurotechnologies to monitor and analyze brain activity, as well as new tools, experimental approaches, theories, and models to integrate neuroscience information across scales and scientific disciplines.

   This priority area is aligned with the objectives of the Administration's BRAIN Initiative. These objectives are focused on development of innovative technologies, tools and instrumentation, computational infrastructure, theory, and models that will accelerate the integration of knowledge

across experimental scales from atomic to behavioral; across multiple science, engineering, and computational disciplines; and across species and lifespans. Expected outcomes include the development of new neurotechnologies, predictive models, and theories of brain and nervous system function that can guide follow-on experimental research and foster further technical and theoretical achievements.

2. Identify the fundamental relationships among neural activity, cognition, and behavior.

   This priority area aims to foster increased understanding of the causal relationships between neuronal activity in the brain, cognitive processes, and behavior. Advancements in this area require increased collaboration among the neuroscience, cognitive science, and behavioral and social science disciplines; adoption of innovative technologies and methods to monitor and manipulate brain activity, such as the recent development of optogenetics; and the utilization of cyber-infrastructure platforms and computational tools for performing multi-scale analysis of neuroscientific and behavioral data. NSF-planned investments are designed to provide an agile means for research teams to form around specific behavioral paradigms and adapt and/or develop technologies and models. Expected outcomes include an increase in the number of such teams working together on specific neural-behavioral paradigms utilizing advanced methods and models.

3. Transform our understanding of how the brain responds and adapts to changing environments and recovers from lost functionality.

   This priority area aims to expand support for exploring the links among the environment, behavior, and brain function, as well as the enhancing and restorative neurotechnologies that can be brought to bear in these areas. NSF research investments will catalyze the formation of new teams to elucidate basic brain mechanisms and their relationships to social and physical environments, cognition and behavior, and related neuroengineering. The expected outcome is measurable progress in developing specific mappings between brain functional/structural changes, changes in behavior and cognition, and changes in psychosocial, external physical, and technological environments; and acceptance of those mappings more widely in the community via citation and use/re-use.

4. Train a new generation of scientists, engineers, and educators for a transdisciplinary, globally competitive workforce in neuroscience and neuroengineering.

   This priority area focuses on development of a scientific workforce for understanding the brain that is better prepared for interdisciplinary and global collaboration, data analysis and sharing, and adoption of new and innovative technologies, tools, and models. In order to transform the workforce, the activities funded under priority areas 1-3 will require special training and professional development for multi-disciplinary research and international collaboration. The expected outcome will be a future workforce fully engaged in and facile with technologies and data science to understand the brain in action and in context.

Results of NSF's cross-foundational and interagency activities have the potential to accelerate scientific discovery and innovation, promote advances in technology, improve the competitiveness of the scientific workforce, and enhance the lives of Americans through improved educational, economic, health, and social institutions. Improved understanding of the brain will promote brain health; enable engineered solutions that enhance, replace, or compensate for lost function; improve the effectiveness of formal and informal educational approaches; and lead to brain-inspired smarter technologies for improved quality of life. Basic research in these areas will also offer novel insights into how cognitive abilities develop and can be maintained and improved throughout the lifespan.

Approach

Multiple divisions of nearly all NSF science and engineering directorates will participate in the proposed activities. During the last two years, a high-level Steering Committee for Understanding the Brain and two programmatic-level working groups were established by NSF senior management under formal charge to ensure cross-directorate coordination of the proposed activities, including those related to NSF's participation in the BRAIN Initiative. In FY 2015, NSF has streamlined these three groups into a single Understanding the Brain Coordinating Group (UtBCG) to improve communication and efficiency related to support for the BRAIN Initiative, neuroscience, and cognitive science research across the Foundation. The UtBCG is charged with ensuring implementation of the programmatic roadmap as well as interfacing with other federal entities and coordinating the formation of an interagency working group to discuss the creation of a National Brain Observatory as specified in the explanatory statement that accompanied the Consolidated and Further Continuing Appropriations Act of 2015 (P.L. 113-235). As NSF has a long history of funding important neuroscience and cognitive science research through specific core programs, many of these ongoing activities in the core programs will not be under direct purview of the UtBCG.

Through existing mechanisms including workshops, DCLs, RCNs, and targeted solicitations and special mechanisms such as EAGERs and Ideas Labs, NSF will bring together the diverse relevant scientific communities in biology, chemistry, behavior, cognitive science, social science, computer science, engineering, physics, psychology, mathematics, and statistics to identify scientific priorities and needed research infrastructure, establish cross-disciplinary standards, integrate data and methods, and catalyze the development of conceptual and theoretical frameworks.

Many science and engineering research communities that are involved in brain-related research and technology development are expected to continue to participate and benefit from these activities. Interagency collaborations through existing programs such as Collaborative Research in Computational NeuroScience (CRCNS), and international collaborations such as those with the U.S. - Israel Binational Science Foundation are engaged.

Investment Framework

UtB Funding by Directorate

(Dollars in Millions)

Directorate/Office	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
Biological Sciences	$33.60	$37.77	$43.40
Computer and Information Science and Engineering	11.58	16.50	28.58
Education and Human Resources	5.17	5.00	11.00
Engineering	8.63	10.99	16.75
Mathematical and Physical Sciences	13.08	14.18	18.70
Social, Behavioral, and Economic Sciences	20.56	22.00	25.00
Office of International Science and Engineering	-	-	0.50
Total	**$92.62**	**$106.44**	**$143.93**

Totals may not add due to rounding.

FY 2014 – FY 2015

In FY 2014, NSF invested $22.62 million in the BRAIN Initiative to catalyze fundamental research and new collaborations across neuroscience, neuroengineering, and cognitive science. An additional $70.0 million, through core research activities, focused on accelerating fundamental research and associated development of new technologies for neuroscience and neuroengineering, bringing the total for UtB to

$92.62 million. Participating directorates funded approximately $10 million in new EAGER awards for innovative approaches and neurotechnologies to understand the brain, following a response to a call for letters of interest that was much greater and wider than anticipated (575 responses received, spanning all relevant science and engineering disciplines). Over the past year, NSF has also continued to engage leaders across all scientific and engineering disciplines through a series of cross-disciplinary workshops that have identified a number of key gaps in scientific understanding of the brain and needed technologies. This input guides NSF's investment strategies for FY 2015 and FY 2016. Such activities will also provide insight into future requests.

In FY 2015, NSF increases its investment to $106.44 million for the UtB activity, with $48.48 million of these funds devoted to projects related to the BRAIN Initiative. These investments will drive integration of research at multiple scales of analysis and accelerate the development of new theoretical, experimental, and analytical approaches, including computational and data-enabled modeling and new neural engineering and technology research and development. Funding will also enable transformative scientific progress toward understanding of the functional dynamics of the brain and complex neural systems, and their interactions with changing physical, technological, and social environments throughout the lifespan.

To understand the full complexity of the brain, it will be crucial to increase collaborations among relevant scientific communities, which have traditionally focused on discipline-specific experimental questions. Consequently, FY 2015 investments will also fund new interdisciplinary and transdisciplinary team formation and workforce development through the development of up to two solicitations and two Ideas Labs sponsored by unique combinations of our disciplinary directorates. One such solicitation, integrative Strategies for Understanding Neural and Cognitive Systems (NSF-NCS), has already been issued by SBE, CISE, ENG, and EHR. It invites bold, potentially transformative, scientifically interdisciplinary proposals around two research themes: Neuroengineering and Brain-Inspired Concepts and Designs; and Individuality and Variation. Funding will also support increases in interagency collaboration, coordination, and communication through the BRAIN Initiative and the efforts of the Interagency Working Group on Neuroscience.

FY 2016 Request

In FY 2016, NSF proposes an increase in investments of $37.49 million (for a total of $143.93 million) for the UtB activity. Within the total, $71.56 million will support activities related to the BRAIN Initiative. NSF will continue the focus initiated in FY 2015 by continuing to employ investment strategies designed to enable the transformational research, engineering, infrastructure development, and training required to accomplish the overall multi-year goal across the priority areas identified earlier:

- **Integrative and transdisciplinary team-based brain research.** NSF will seek proposals from interdisciplinary teams of researchers poised to promptly address targeted issues, such as innovative experimentation in realistic and complex environments; neurotechnology development; computational modeling and simulation; and quantitative theory development. Such teams will also contribute to defining requirements for cyberinfrastructure and analytic tools required to address the expected data surge from these experimental, modeling, and theoretical efforts. One major objective of these investments is to establish truly transdisciplinary team-based brain research: integrated collaborative research environments that rise above existing disciplines. NSF will use an array of existing funding mechanisms, potentially including traditional grants, special solicitations, RCNs, centers, EAGERs, and INSPIRE awards.
- **Data science, infrastructure, and tool development for understanding the brain.** NSF will provide new opportunities for building infrastructure and analytic capabilities for data integration and interpretation across scales and disciplines, with the objectives of transforming data to knowledge for advances in cognitive science, neuroscience, neuroengineering, and research and education. Proposals will also be sought to address outcome goals of establishing policies and community practices for data management, open access, data sharing, and methods for exploiting large-scale

neuroscience and behavioral data. A major NSF objective will be to encourage stronger connections with other NSF-funded communities that are dealing with similar Big Data issues and multi-modal data integration, such as those focused on earth, ocean and climate observing, high energy physics, astronomy, and related large-scale computing. NSF will fund planning workshops and other community engagement activities to identify and clarify specific needs for infrastructure and analytic tools.

- **Specialized training and professional development in multi-disciplinary and international research and large-scale data management and analysis.** To develop a scientific workforce that is better prepared for interdisciplinary and global collaboration in understanding the brain, NSF will provide opportunities for training and professional development of supported personnel (students, postdoctoral scholars, and principal investigators) in areas of multi-disciplinary research and international collaboration. Opportunities for multi-disciplinary training will require mentoring and professional activity in collaboration and co-located collaborations with experts from intellectually distinct disciplines. Supporting this effort, the NSF Research Traineeship program (NRT) will feature Understanding the Brain as one of its emphasis areas. For international training, opportunities must be provided for students and professionals to train and/or collaborate abroad for a defined period of time. Award supplements will be tracked separately for evaluation purposes.

Evaluation Framework

A range of impacts and endpoints are anticipated from NSF's UtB activities. Advanced technological, experimental, analytical, and theoretical innovations will expand the scope and scale of fundamental investigations across scientific and engineering disciplines to advance the understanding of the brain in action and in context and promote the translation of discoveries to societal benefits. The cross-disciplinary collaboration focus will accelerate establishment of policies and community practices for data management, open access, data sharing, and methods for handling and analyzing large-scale neuroscience and behavioral data. Finally, NSF workforce investments will increase the human capital and infrastructure needed to serve multi-scale, multi-level interdisciplinary neuroscience and cognitive science.

The UtBCG will oversee evaluation of the progress on scientific and programmatic activities. Assays of success of each priority area will be compared against the expected outcomes described above, using measures including:

- Priority Area 1: level of deployment and adoption of innovative technologies by the scientific community via reuse and citations;
- Priority Area 2: increases in the number of transdisciplinary teams funded to work and publish in this area;
- Priority Area 3: acceptance by the research community of new mappings between brain functional/structural changes and identified changes in psychosocial, external physical, and technological environments; and
- Priority Area 4: number of participants, and demographics of collaborations in publications before and after the investment period.

The progress of the implementation of this investment is being monitored and reviewed quarterly as part of a performance goal in FY 2015. For more information about monitoring key program investments, see the FY 2014 Annual Performance Report in the Performance chapter.

IMPROVING UNDERGRADUATE STEM EDUCATION (IUSE)

$134,580,000
+$29,180,000 / 27.7%

Overview

In FY 2016, the National Science Foundation (NSF) will continue and expand implementation of a coherent, coordinated agency-wide investment in undergraduate science, technology, engineering, and mathematics (STEM) education through the Improving Undergraduate STEM Education (IUSE) initiative, launched in FY 2014. IUSE is intended to increase the numbers, broaden the diversity, and improve the preparation of students who will enter STEM professions and enhance the readiness of the public to understand and use STEM in their careers and lives. These goals, and the development and implementation of effective undergraduate education programs, will be achieved through a vibrant partnership of scientists, engineers, mathematicians, and education experts.

A diverse and globally engaged U.S. STEM workforce, able to innovate and well prepared for the changing scientific landscape, is crucial to the Nation's health and economy. Yet there is deep concern across the private sector, government, and academe that access to higher education and high quality STEM education in particular, is unevenly available to our Nation's youth. It is critical that a diverse pool of undergraduates taking STEM courses and earning STEM degrees is adequately prepared with the STEM skills and knowledge to meet growing demands and to lead in emerging STEM areas. As the Nation's demographics shift rapidly, it is even more crucial to ensure the engagement of people from groups that traditionally have been underrepresented in STEM so that the diverse talent of the Nation is fully utilized. Recent reports of the President's Council of Advisors on Science and Technology (PCAST)[1] and the National Academies[2,3] support the critical importance of broad engagement. The National Science and Technology Council Committee on Science, Technology, Engineering, and Mathematics Education (CoSTEM) identified undergraduate STEM education as a priority in its 2013 Federal STEM Education five-Year Strategic Plan.[4]

With an aim to rapidly and dramatically improve U.S. undergraduate STEM education, NSF is undertaking strategic coordination and integration of all its undergraduate STEM education investments within the IUSE framework. The NSF IUSE framework, developed in FY 2014, is built upon a knowledge base accumulated from decades of research, development, and best practices across the Nation in STEM undergraduate education. It is designed to accelerate improvement in undergraduate STEM education and yield measureable outcomes. IUSE integrates theories and findings from education research to support the partnerships necessary for frontier science and engineering research.

Excellent undergraduate education accessible to the full range of talent in the Nation is critical to the advancement of science. IUSE supports two of NSF's Strategic Goals: Goal 1: Transform the Frontiers of Science and Engineering and Goal 2: Stimulate Innovation and Address Societal Needs through Research and Education.

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[1] President's Council of Advisors on Science and Technology (2012) *Engage to Excel*: *Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics*, www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-engage-to-excel-final_feb.pdf

[2] National Research Council (2011) *Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads*. Washington, DC: National Academies Press, www.nap.edu/catalog.php?record_id=12984

[3] National Research Council (2012) *Discipline-based Education Research: Understanding and Improving Learning in Undergraduate Science and Engineering.* Washington, DC: National Academies Press, www.nap.edu/catalog.php?record_id=13362

[4] National Science and Technology Council, Committee on STEM Education (2013) *Federal Science, Technology, Engineering, and Mathematics (STEM) Education 5-Year Strategic Plan.* www.whitehouse.gov/sites/default/files/microsites/ostp/stem_stratplan_2013.pdf

Total Funding for IUSE

(Dollars in Millions)

FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
$81.84	**$105.40**	**$134.58**

Goals

The long-term goal of the suite of IUSE investments is to increase the numbers, broaden the diversity, and improve the undergraduate preparation of STEM professionals. The IUSE initiative is grounded in three long-term goals for NSF investments in undergraduate STEM education:

- **Improve STEM Learning and Learning Environments**: Improve the knowledge base for defining, identifying, and implementing innovative undergraduate STEM instruction (in all NSF-supported disciplines) that leads to improved student learning outcomes and fosters widespread use of evidence-based resources and pedagogies in undergraduate STEM education practice.
- **Broaden Participation and Institutional Capacity for STEM Learning**: Increase the number and diversity of undergraduate students recruited and retained in STEM fields and career pathways by improving the evidence base for successful strategies to broaden participation and implementing the results of this research.
- **Build the Professional STEM Workforce for Tomorrow**: Improve the preparation of undergraduate students so they can succeed as productive members of the future STEM workforce, regardless of career path, and be engaged as members of a STEM-literate society.

Approach

NSF will continue its agency-wide approach of using an IUSE framework which is built on the recommendations of cross-directorate design and implementation committees. The key principle guiding IUSE is that NSF investments in undergraduate education will be focused, strategic investments centered on addressing the greatest challenges in U.S. undergraduate STEM education. A significant obstacle to the development of U.S. STEM talent is undergraduate student retention. The U.S. lags behind much of the world in college degree attainment and production of STEM scientists.[5] Across STEM fields, non-Asian racial and ethnic groups continue to be underrepresented in bachelor's degree attainment relative to their shares of the population.[6] The primary IUSE investment, managed through the Directorate for Education and Human Resources (EHR), is to study educational outcomes for undergraduate improvement and to scale that improvement across all STEM domains and all types of undergraduate institutions. The Directorates for the Biological Sciences (BIO), Geosciences (GEO), and Engineering (ENG) all have discipline-specific investments, designed within the IUSE framework that will continue as part of the effort.

In FY 2015 and beyond, all directorates will be engaged in expanding the focus of IUSE to include undergraduate research courses, research experiences for undergraduates, and common outcomes. NSF's Research Experiences for Undergraduates (REU) sites and supplements programs fall within the IUSE purview, with budget and award decisions remaining within individual directorates. IUSE is governed by an IUSE Council comprised of Assistant Directors (ADs) and coordinated by the EHR AD.

Additionally, EHR's programs that focus on undergraduate education activities for minority serving institutions (MSIs) and groups underrepresented in STEM (e.g., Louis Stokes Alliance for Minority

[5] President's Council of Advisors on Science and Technology (2012) *Engage to Excel*: *Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics,* www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-engage-to-excel-final_feb.pdf

[6] www.nsf.gov/nsb/sei/edTool/data/college-14.html

Participation (LSAMP), Historically Black Colleges and Universities Undergraduate Program (HBCU-UP), Tribal Colleges and Universities Program (TCUP)) will be more fully integrated into IUSE through joint outreach, panels, co-funding, and partnerships. These and other activities ensure that MSIs can make the transition from a focus on capacity building to being part of the broader efforts to improve undergraduate STEM education. For example, effective models used at HBCUs and Hispanic-serving institutions (HSIs) can be studied to provide information for scaling and adaptation in other institutions.

NSF will fund a range of project types from foundational research to scale-up and effectiveness studies. Funding will be available for individual investigators and research teams with expertise cutting across one or more STEM disciplines and STEM education research, including discipline-based education research, cognitive science, and the social and behavioral sciences. The intent of IUSE is to build on NSF's unique strengths across the STEM disciplines and STEM education to focus on sustained improvements towards the goals described above. Such research is inherently interdisciplinary in nature. Aligned with the funding strategy will be the development of robust, common indicators and metrics to gauge progress towards the goals of IUSE.

There is an NSF-wide commitment to employing common goals and outcome measures, tailoring investments to address particular disciplinary challenges and understanding the differences, and increasing education investment in new and emerging areas of science. In FY 2016, all investments that are included within the framework will use a common name (e.g., "Improving Undergraduate STEM Education") with a subtitle, as appropriate, to signify a more specific focus. Investments/program dollars will remain in home directorates and divisions, but solicitations and program announcements will incorporate or reference agreed-upon language describing the framework and how the particular investment or program is situated within it.

Investment Framework

IUSE Funding by Directorate

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
Biological Sciences	$1.82	$2.50	$2.50
Computer and Information Science and Engineering	-	2.00	-
Education and Human Resources	74.57	84.00	120.08
Engineering	5.45	6.00	6.00
Geosciences	-	10.90	6.00
Total	**$81.84**	**$105.40**	**$134.58**

FY 2014 – FY 2015

IUSE was launched in FY 2014 in EHR with funding for awards in foundational and exploratory research, design and development implementation, and scale-up and effectiveness studies. This initial IUSE call attracted 1,097 proposals from across the disciplines in STEM education and an additional 600 applications to participate in the themed Ideas Labs through EHR partnerships with BIO, GEO, and ENG, in an attempt to clarify discipline-specific needs and solution approaches. In FY 2014, ENG in partnership with EHR and CISE announced a solicitation for Professional Formation of Engineers: Revolutionizing Engineering Departments (PFE: RED) to enable engineering departments to lead the Nation by successfully achieving significant, sustainable changes necessary to overcome long-standing issues in their undergraduate programs and educate inclusive communities of engineering students prepared to solve 21st century challenges.

In FY 2015, IUSE coordination encompasses all investments in research and development that are critical for curricular improvement in undergraduate STEM education, within formal and informal learning environments, including those that:

- Use and build evidence about improved STEM instructional practices, with a focus on increased retention and persistence;
- Invite the successful participation and retention in STEM of students from groups traditionally underserved and underrepresented in STEM;
- Design and study innovative learning opportunities, including cyberlearning;
- Create, implement, and test program, curricular, course, and technology-driven models;
- Develop, implement, and test creative approaches for adoption of education research into disciplinary teachings;
- Develop and validate assessments/metrics for undergraduate STEM learning and instructional practice; and
- Conduct fundamental research on issues of undergraduate STEM teaching and learning.

FY 2016 Request

In FY 2016, the IUSE framework will be expanded to incorporate portfolio areas that support NSF's direct investments in students through fellowships and scholarships, and investments in students' participation in research experiences. It will be critical to retain directorate-and discipline-specific foci while at the same time basing undergraduate education investments on evidence, and using our programs as a basis for research and evaluation to ensure that we understand the impact and affordances of specific approaches to improvement. The refined IUSE framework that will be published in late FY 2015 will inform further coordination across all disciplines. In addition, all undergraduate programs across NSF will again be inventoried and reviewed to identify additional, emerging synergies and collaboration opportunities.

IUSE increases $29.18 million in FY 2016, allowing expanded emphasis on bringing evidence-based instructional practices to scale for both the general improvement of STEM learning, and also to expand effective discipline-specific innovations. A key focus will be on strategies for engaging undergraduates in their first two years in authentic research experiences both in courses and in other settings. The IUSE investment within EHR will include partnerships with EHR programs focused on minority-serving institutions. GEO will continue to refine and align IUSE: Pathways into Geoscience (GEOPATHS) with the revised IUSE framework, as will ENG with the IUSE: RED program. Both of these programs emphasize the broadening participation and workforce development elements of IUSE. GEOPATHS will specifically address minority-serving institutions, furthering the FY 2016 introduction of building models of effectiveness for undergraduate STEM improvement in minority-serving institutions into the IUSE effort. BIO will continue with two IUSE programs, Partnerships in Undergraduate Life Science Education (PULSE), Research Coordination Networks in Undergraduate Biology Education (RCN-UBE), that emphasize the scaling of effective education practices within the biology undergraduate education community. The IUSE investments in fellowships and scholarships also will build on evidence to create robust, STEM learning environments for all students. All directorates will continue to manage and support REUs, informed by findings from education research that can strengthen the experiences and providing data that enhance our understanding of how to best offer research experiences that will benefit a wide range of students in varied settings and fields.

FY 2017 – FY 2020

As NSF accumulates a broader and deeper set of findings and evidence-based practices for improving undergraduate STEM education, we anticipate increased emphasis in later years in several areas. These include increasing access to undergraduate STEM learning and research experiences through technology, citizen science approaches, and apprenticeship and intern models; transition from pre-college to undergraduate STEM education; and transitions from undergraduate STEM education to the workplace and to graduate school. IUSE will also be coordinated with the NSF INCLUDES (Inclusion across the Nation of Communities of Learners that have been Underrepresented for Diversity in Engineering and Science) pilot, particularly the Networks for STEM Excellence, and will incorporate the "collective impact" approach[7] that is underway in higher education efforts related to college access and improvement.

Evaluation Framework

A major IUSE emphasis in FY 2016 will be the implementation of an NSF-wide crosscutting evaluation program, using the metrics that are under development in FY 2015. This work will coordinate with the ongoing CoSTEM effort across government to identify shared metrics. To support the activities of both IUSE and the CoSTEM implementation of the undergraduate strategic objectives of the Federal STEM Education 5-Year Strategic Plan, IUSE will fund a resource network to help with the common data collection necessary for a cross-agency evaluation effort.

IUSE metrics and indicators will be tailored to the three investment strategies; the development of these metrics and indicators will be a major focus in FY 2015. In FY 2016, the NSF Evaluation and Assessment Capability will work with EHR evaluation experts to implement data collection plans across the IUSE portfolio.

[7] www.ssireview.org/articles/entry/collective_impact

INCLUSION ACROSS THE NATION OF COMMUNITIES OF LEARNERS THAT HAVE BEEN UNDERREPRESENTED FOR DIVERSITY IN ENGINEERING AND SCIENCE (NSF INCLUDES) $15,000,000

Overview

In FY 2016, NSF will launch NSF INCLUDES (Inclusion across the Nation of Communities of Learners that have been Underrepresented for Diversity in Engineering and Science), a comprehensive national initiative using a collective impact approach to increase the preparation, participation, advancement, and contributions of all scientists and engineering students, including those who have been traditionally underserved and/or underrepresented in all fields of science, technology, engineering, and mathematics (STEM). This includes, e.g., underrepresented ethnic/racial groups, women and girls and persons with disabilities. Diversity is a critical driver of excellence in research and innovation in STEM in the 21st century,[1] as the future of science depends upon diversity of thought that will strengthen the scientific infrastructure. Full representation of all of America's STEM talent is a competitive advantage to enrich this diversity of thoughts and approaches, and thus advance science and engineering knowledge and the wellbeing of the Nation.

Currently the U.S. STEM enterprise faces numerous challenges to broadening participation including: under-participation across demographic groups; under-preparation and lack of opportunity for members of all demographic groups to learn meaningful, relevant STEM content; under-resourcing for some groups leading to growing disparities; and under-production of a diverse STEM workforce to ensure global competitiveness. NSF INCLUDES is designed to mobilize the STEM communities to bring renewed focus to solving broadening participation (BP) challenges by addressing a set of "bold visions for inclusion" at the national level, collectively. The initiative will support two of NSF's Strategic Goals and associated objectives: *Goal 1*: Transform the Frontiers of Science and Engineering – Objective 2: Integrate education and research to support the development of a diverse STEM workforce with cutting-edge capabilities and *Goal 2*: Stimulate Innovation and Address Societal Needs through Research and Education – Objective 1: Strengthen the links between fundamental research and societal needs through investments and partnerships.

Total Funding for NSF INCLUDES

(Dollars in Millions)

FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
-	-	**$15.00**

Goal

The long-term goal of NSF INCLUDES is to fund new research, models, and partnerships that lead to demonstrable progress – moving the needle – in meeting the challenge of broadening participation in science and engineering. With special attention to the cross-cutting areas of inclusion, relevance, scalability, and sustainability, NSF will support a new set of NSF strategic investments to expand the culture of diversity in science and engineering across all sectors.

[1] Page, S. E.; *The Difference: How the Power of Diversity Creates Better Groups, Firms, Schools, and Societies*; Princeton University Press, 2007.

Approach

NSF will employ an agency-wide broadening participation campaign that is complementary to key Administration diversity efforts in STEM, such as: the White House College Opportunity initiative;[2] the My Brother's Keeper initiative;[3] the annual White House Science Fair;[4] the Women in STEM virtual resource and the Equal Futures Partnership to engage and attract more females to STEM education and STEM careers;[5] the Technology Showcase to demonstrate the power of technology to level the playing field for persons with disabilities;[6] and the Tech Inclusion Champions of Change.[7]

In FY 2016, NSF INCLUDES will pilot two new models. The first (Network Pilot) will impact inclusion at large-scale via professional and social networks and effective technologies designed for collective impact. The second (Youth Empowerment Pilot) will create a new approach to empowering youth by engaging them directly in STEM, and will catalyze innovative discipline-specific initiatives. Overall co-coordination will be provided by the Office of Integrative Activities (OIA) Head and the Directorate for Education and Human Resources (EHR) Assistant Director (AD), in conjunction with NSF senior management and the NSF INCLUDES Working Group, comprising representatives from all directorates and offices. The Network Pilot will be led by OIA, and the Youth Empowerment pilot will be led by EHR. All of NSF's directorates will engage in domain-specific elements of NSF INCLUDES. This initiative will require the use of formal solicitations and Dear Colleague Letters to make awards and cooperative agreements, as well as post-award supplements. NSF INCLUDES is intended as a six-year activity, FY 2015 through FY 2020. The pilot activities will be three-year efforts with a review in the third year to determine next steps.

Investment Framework

NSF INCLUDES Funding by Directorate
(Dollars in Millions)

Directorate/Office	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
BIO	-	-	$1.40
CISE	-	-	1.78
EHR	-	-	3.00
ENG	-	-	1.40
GEO	-	-	2.44
MPS	-	-	2.60
SBE	-	-	0.50
IA	-	-	1.88
Total, NSF INCLUDES	**-**	**-**	**$15.00**

Totals may not add due to rounding.

FY 2014 – FY 2015

NSF INCLUDES will be designed as a coordinated strategy responsive to the Committee on Equal Opportunities in Science and Engineering's (CEOSE) recommendation to build capacity and knowledge for catalyzing a national effort to make measurable progress on broadening participation in America's STEM workforce. In FY 2014, NSF established a Broadening Participation Working Group to develop

[2] www.whitehouse.gov/the-press-office/2014/08/13/fact-sheet-improving-college-opportunity
[3] www.whitehouse.gov/my-brothers-keeper
[4] www.whitehouse.gov/science-fair
[5] www.whitehouse.gov/blog/2013/09/23/equal-futures-partnership-new-agenda-progress
[6] www.whitehouse.gov/blog/2010/07/20/power-technology-power-equality
[7] www.whitehouse.gov/champions/tech-inclusion

options for the CEOSE-recommended bold new initiative, including the leverage of the current knowledge base of research and best practices for broadening participation. Furthermore, NSF INCLUDES will be customized, as needed, to specific diversity challenges in disciplines identified by directorate advisory committees and reports from national disciplinary societies. A foundational pillar will be developed in FY 2015 by fostering a national conversation to identify a set of community-driven "bold visions" for broadening participation. Community and stakeholder engagement to shape NSF INCLUDES and its bold vision development activities will be staged over two fiscal years, FYs 2015 and 2016.

FY 2016 Request

In FY 2016, based on the aforementioned new models that focus on networks and youth empowerment, respectively, two NSF-wide pilot programs will be launched: NSF INCLUDES: Networks for STEM Excellence and NSF INCLUDES: Empowering All Youth for STEM. Both pilots will provide support to the most innovative projects to collectively achieve the set of "bold visions." These "bold visions" will be approaches that allow for coordinated, focused attention to a small set of clearly defined goals, where individual organizations agree to work together to aim at specifics that have been demonstrated to be effective in a number of settings. The pilots will be designed to build on evidence emerging from existing efforts, as well as all extant evidence, to extend these efforts in new directions. Additionally, these pilot programs will be deliberately designed to engage communities and sectors in partnerships that extend beyond the communities that typically seek NSF funding, including business and industry.

The Networks for STEM Excellence pilot will catalyze the implementation of networks consistent with CEOSE's and the NSF Broadening Participation Working Group's recommendations for centers/institutes and partnerships.[8] Moreover, this pilot builds on extensive NSF experience in funding centers, networks, alliances, systemic approaches, and the research evidence about the effectiveness of such approaches in making lasting change. The key idea is to leverage existing programs, people, organizations, alliances, and institutions by providing resources that will allow the formation of new networks and synergies, to form NSF's next generation of BP investments. This pilot is expected to achieve greater multiplicative impacts than prior efforts. It seeks transformative scale results to grow what works, building on strategies such as distributed platforms of effective networks, training others to deliver the solution, unbundling and scaling up the parts that have the greatest impact, strengthening a field of key players and building communities of experts and practitioners, changing public systems, innovating to drive down costs, and engaging the community (for example, the Year Up model).[9] By exploiting the inherent and structural power of professional/social networks, networks will be encouraged to use technological innovations as part of their approach to sharing information and scaling ideas. Features of this approach will include shared goals across institutions and partners; common outcomes and metrics, and strategies for outreach and communication (for example, collective impact).[10] Networks will identify one or more of the NSF INCLUDES bold visions as the drivers for their work.

The Empowering All Youth for STEM pilot will invite proposals to design, implement, and assess models to ignite greater demand for STEM learning opportunities for middle grades youth. In contrast with more traditional approaches to informal STEM learning, this pilot will emphasize engaging young people more directly in the kinds of STEM learning opportunities that they seek. It will build on literature about such important variables as grit, collaborative problem solving, growth mindset, and motivation. Empowering All Youth for STEM will catalyze innate curiosity, generate excitement, and engage learners in experiencing science and technology learning and participation on their terms and to build on their own emerging curiosity and experiences in STEM. The projects should propose ways of empowering youth

[8] The NSF BP Working Group recommendations will be available by end of FY 2015.
[9] www.ssireview.org/articles/entry/transformative_scale_the_future_of_growing_what_works
[10] www.ssireview.org/articles/entry/collective_impact

and building their capacity to seek out existing or develop new local, regional, national, and international resources to feed their appetites for STEM and to support them in engaging in STEM experiences. New NSF investments in this pilot will go to community organizations, informal learning enterprises, developers of technology, cyberlearning experts, and creative partnerships that can leverage other stakeholders with shared interest in this space, and that can focus in high-needs areas and on populations that are underrepresented in STEM. Proposers may identify one or more of the "bold visions" that are driving their efforts.

In addition to the two pilot programs, a third focus in FY 2016 is the expansion and re-framing of directorate-based broadening participation efforts to align for greater impact. This component of NSF INCLUDES will leverage disciplinary opportunities to fill STEM positions in key growth areas with scientists and engineers from underrepresented groups; and to ensure that diversity of background and perspectives drives innovation as well as a sustained, coordinated approach to BP.

FY 2017 – FY 2020

NSF will continue to make the case for and invest in education, mentoring, and research in order to create STEM experiences to empower every segment of the American population to succeed regardless of demographic characteristics. NSF INCLUDES will capitalize on NSF's role in basic research across all fields of science and engineering and across all levels and venues of STEM education. The ongoing activities in FY 2017 and beyond include: supporting innovative projects to achieve new levels of partnerships and scale as well as generate new knowledge to inform future broadening participation efforts; engaging the NSF Evaluation and Assessment Capability in the oversight responsibilities for assessing and evaluating the NSF INCLUDES portfolio, including a three-year review to determine next steps; and continuing the convening of stakeholders to maintain the national momentum for diversifying the STEM enterprise and disseminate promising/best practices.

Evaluation Framework

In FY 2016, an external evaluation will be contracted for NSF INCLUDES monitoring and evaluation. Evaluation will be driven by a focus on the "bold visions" and on the design of indicators and measures for tracking NSF's collective progress toward achieving them. External evaluation experts and NSF staff will develop and refine the theory of action/logic framework for each of the major investment goals of NSF INCLUDES, including annual metrics and ambitious short- and long-term targets (three-year and five or more years, respectively). To be successful, NSF INCLUDES must be systemic, have impact at scale, and be sustainable. Key to this broader impact of the initiative is an evidence-based approach that drives management decision-making, mid-course corrections, improvements, and enhancements for yields greater than incremental progress. Additionally, tracking studies will be employed to determine the contributions to excellence, equity, diversity and inclusion in STEM.

NSF INCLUDES provides the opportunity to implement a coordinated approach for evaluating ongoing efforts. Therefore, results from NSF INCLUDES will strengthen, improve, or refine ongoing programs. This investment priority will be closely monitored for breaking new ground in both assessment practices and innovative solutions for addressing the underrepresentation challenge in STEM. This will happen through, for example, the use of a portfolio approach and innovative text-mining tools for portfolio analysis. The development of common cross-directorate BP performance goals and milestones within the context of NSF's broader impacts criterion will promote bold BP actions that will help ensure the return on the investment of NSF INCLUDES. The progress of the implementation of this investment will be monitored and reviewed quarterly to ensure that it is on track as part of a FY 2016 performance goal. For more information about monitoring key program investments, see the FY 2016 Annual Performance Plan in the Performance chapter.

MAJOR INVESTMENTS IN SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS (STEM) GRADUATE EDUCATION

Overview

The future of science and engineering, and our Nation's ability to contribute significantly to the solution of global problems, depends on human capital. A diverse workforce with advanced research training is essential for transforming the frontiers of science and engineering. NSF's commitment to advancing science, technology, engineering, and mathematics (STEM) and developing human capital in tandem has been a hallmark of the agency's investments since its founding in 1950. As the 21st century progresses, the nature and practice of research and development in the STEM fields, as well as the growing role of STEM experts across a wide range of career areas, are evolving rapidly. Increasingly, research is undertaken as a team effort, with collaborators across institutions, across national boundaries, and across educational levels. Interdisciplinary approaches are needed to solve complex societal problems, fuel the production of scientific advances, take scientific findings to scale through innovation, and apply scientific solutions across settings. The growth of computationally intensive and data-enabled science has changed the knowledge and experience requirements of scientists across fields. With these changes, graduate education in STEM must continue to evolve in order to provide a supply of scientists and engineers who not only meet the needs of the emerging STEM enterprise, but who also have the knowledge, skills, and preparation to advance it, both within and outside of academia.

NSF makes a substantial investment in STEM graduate education through traineeship and fellowship mechanisms, although the majority of NSF's investment in graduate students comes through faculty research grants supporting research assistants.[1] To underscore the importance of these investments and to plan for the future, NSF is developing a five-year strategic plan for its investments in graduate students and graduate education; the target completion date is June 1, 2015. This plan builds on four related efforts: 1) the recommendations of the National Science and Technology Council's Committee on Science, Technology, Engineering, and Mathematics Education (Co-STEM) 5-Year Strategic Plan;[2] 2) on-going interagency discussions about leveraging assets; 3) recent national reports on graduate education;[3,4,5,6] and 4) NSF-wide efforts to ensure that its many forms of investment in graduate education form a coherent agency strategy.

NSF's collective investments in graduate education support two of NSF's Strategic Goals and corresponding objectives: *Goal 1*: Transform the Frontiers of Science and Engineering – Objective 2: Integrate education and research to produce a diverse STEM workforce with cutting-edge capabilities and *Goal 2*: Stimulate Innovation and Address Societal Needs through Research and Education – Objective 2: Build the capacity of the Nation to address societal challenges using a suite of formal, informal, and broadly available STEM educational mechanisms.

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[1] At NSF, about 40,000 graduate students are supported annually at a level of about $1 billion.

[2] National Science and Technology Council, Committee on STEM Education (2013) *Federal Science, Technology, Engineering and Mathematics (STEM) 5-Year Strategic Plan,* www.whitehouse.gov/sites/default/files/microsites/ostp/stem_stratplan_2013.pdf

[3] Council of Graduate Schools (2012) *Pathways through Graduate School and Into Careers,* http://pathwaysreport.org/rsc/pdf/19089_PathwaysRept_Links.pdf

[4] National Institutes of Health (2012) *Biomedical Research Workforce Working Group Report,* http://acd.od.nih.gov/biomedical_research_wgreport.pdf

[5] American Chemical Society (2012) *Advancing Graduate Education in the Chemical Sciences,* www.acs.org/content/dam/acsorg/about/governance/acs-commission-on-graduate-education-summary-report.pdf

[6] National Research Council (2012) *Research Universities and the Future of America,* www.federalrelations.wisc.edu/docs/FutureofAmericaU.pdf

Goals

The goal of NSF's collective investments in STEM graduate education and STEM graduate students is to prepare a diverse workforce with advanced research training that is equipped to transform the frontiers of science and engineering, and to prepare professionals, through various levels and approaches to graduate education, to participate and innovate in STEM intensive careers in ongoing and emerging areas.

NSF's graduate STEM investments will:

- Support training in areas of national science and engineering priorities.
- Catalyze development of innovative models for graduate education with potential for scalability.
- Build the research knowledge base to inform improvements in graduate education.
- Promote professional development of graduate students for both academic and non-academic careers.

NSF will establish frameworks for graduate education investments that can be applied across fellowship, traineeship, and research assistantship investments.

Approach

NSF's extensive investment in graduate education spans the entire agency through a set of traineeship and fellowship programs, in addition to research assistantships and other investments that are discipline-specific. The two primary agency-wide programs are the Graduate Research Fellowship (GRF) program and the NSF Research Traineeship (NRT) program, both of which are administered for the agency by the Directorate for Education and Human Resources (EHR). Management of these programs is guided by input from a cross-directorate working group with representatives from all relevant NSF directorates and offices. Each group contributes to programmatic plans, policy decisions, and the application review processes.

Programs that support graduate STEM education, as well as other education levels, are CyberCorps®: Scholarships for Service (SFS), a cybersecurity education and workforce development program; and three programs that support STEM education and workforce development: Robert Noyce Teacher Scholarship (NOYCE); Louis Stokes Alliance for Minority Participation Bridge to the Doctorate (LSAMP – BD); and the H1-B visa-supported NSF Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM) program.

Across the Research and Related Activities (R&RA) directorates, there are dissertation completion award programs, travel grant programs, and traineeship-style support within large centers. Additionally, in all directorates, there is support for research assistants on research awards. Taken together, this broad suite of programs and investments comprises the NSF investment in the graduate education of the STEM research and education workforce of the future.

The approach in FY 2016 will include the development and revision of solicitations for fellowship and traineeship programs that align with the five-year NSF Graduate Education Strategic Plan currently being developed. The effective collaboration underway across NSF directorates in the preparation of the STEM workforce through graduate education will continue and expand. The agency will also develop common outcomes of NSF investments in graduate education and graduate students that can be used agency-wide. A major emphasis in FY 2016 will be the development of expanded opportunities for professional development of graduate students.

Investment Framework

The NSF Graduate Education Strategic Plan will serve as the foundation for our efforts in FY 2016 and beyond. NSF expects to focus on: strengthening the professional development opportunities for graduate students in all of our programs; increasing investment through EHR programs in research to better understand how to improve the learning experiences and professional preparation of STEM graduate students; analysis and pilot activities in fellowship and research assistantship investments to promote cohort models within and across institutions and disciplines; and implementation of more comprehensive tracking and follow-up for NSF graduate student investments. Initiatives begun in FY 2014 to enhance the capacity of minority-serving institutions to increase the number of students who successfully compete for GRF awards will continue. The development of a pilot study of the feasibility of data collection of early career outcomes of GRF recipients, launched in FY 2013, will also continue. This activity is being conducted in partnership with the NSF Evaluation and Assessment Capability (EAC), the EHR Evaluation Group, and the National Center for Science and Engineering Statistics. In FY 2016, data will become available from the first survey of GRF PhD recipients participating in this study.

Graduate Research Fellowship (GRF) Program

The goal of GRF is to help build the U.S. STEM human capital necessary to ensure the Nation's leadership in advancing innovations in science and engineering. To enhance professional development for graduate students, address agencies' workforce needs, and strengthen interagency collaboration, GRF launched the Graduate Research Internships Program (GRIP) in FY 2015 to offer GRF fellows internships in government laboratories and other federal research settings. International internships for GRF fellows are available through the Graduate Research Opportunities Worldwide (GROW) program. GRF selects, recognizes, and financially supports graduate students with demonstrated high potential for excellence in STEM and in their ultimate chosen career. Applications are welcomed from students in all STEM disciplines and in STEM interdisciplinary areas. In FY 2016, NSF will support approximately 2,000 new fellowships. GRF awardees receive a competitive stipend, $34,000 per year, and a cost of education allowance (COE) of $12,000 per year for three years of their choosing within a five-year award window.

GRF Funding by Account

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
Education and Human Resources	$149.62	$166.72	$168.75
Research and Related Activities	150.00	166.72	168.75
Total GFRP	**$299.62**	**$333.44**	**$337.50**
Number of New Fellows	2,000	2,000	2,000
Projected Fellows on Tenure[1]	5,927	7,000	7,000

Totals may not add due to rounding.

[1] Fellowship tenure status is the period of time during which fellows actively utilize the fellowship award to pursue an advanced degree in a STEM field.

NSF Research Traineeship (NRT) Program

NRT, an NSF-wide program, aims to create and promote new, innovative, effective, and scalable models for STEM graduate student training in emerging research emphasis areas. NRT provides a mechanism for developing a knowledge base about the implementation and impact of innovative graduate traineeship programs and graduate education policies. The NRT program is distinguished from prior traineeship programs by its emphasis on training for multiple career pathways, rotating priority research themes, inclusion of both masters and doctoral students, a broader definition of trainees, and greater budgetary and programmatic flexibility.

In the NRT program, the priority research theme area for FY 2014 and FY 2015 addresses fundamental challenges advancing computation- and data-enabled science and engineering. Proposals for FY 2016 will be solicited in two additional NSF-wide priority research areas: Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS) and Understanding the Brain (UtB). Investigator-initiated interdisciplinary and disciplinary-themed proposals will also be accepted. The goal is to design and create innovative graduate education approaches in areas of national need and/or emerging scientific priority. The Innovation in Graduate Education track is being launched in FY 2015 to develop and study innovative graduate education models and conduct research needed to inform implementation, adaptability, and scalability and will be sustained in FY 2016.

NRT Funding by Directorate[1]

(Dollars in Millions)

	FY2014 Actual	FY 2015 Estimate	FY 2016 Request
Biological Sciences	$3.12	$3.39	$2.33
Computer and Information Science and Engineering	1.40	13.38	9.69
Education and Human Resources[2]	13.93	28.27	35.38
Engineering	4.72	2.85	2.59
Geosciences	2.21	6.63	4.43
Mathematical and Physical Sciences	4.64	4.51	4.47
Social, Behavioral, and Economic Sciences	3.38	2.52	3.12
Total	**$33.40**	**$61.55**	**$62.01**

Totals may not add due to rounding.

[1] Outyear commitments to the Integrative Graduate Education and Research Traineeship (IGERT) program are included in the NRT line and total $32.81 million in FY 2014, $12.12 million in FY 2015, and $10.33 million in FY 2016.

[2] EHR's NRT funding includes $7.0 million for Innovation in Graduate Education (IGE) as a track within the NRT program.

Additional Programs Supporting STEM Education and Workforce Development at the Graduate Level

CyberCorps®: Scholarships for Service (SFS) Program

The SFS program addresses cybersecurity education and workforce development. The Scholarship Track provides funding to institutions for awarding scholarships to undergraduate and graduate students in cybersecurity. Approximately 37 percent of the Scholarship Track supports graduate program activities. In return for their scholarships, tuition, fees, health insurance, travel and book allowances, recipients work after graduation for a federal, state, local, or tribal government organization in a position related to cybersecurity for a period equal to the length of the scholarship. The Capacity Track seeks innovative proposals leading to an increase in the ability of the U.S. higher education enterprise to produce cybersecurity professionals.

CyberCorps®: Scholarships for Service (SFS)

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
SFS	$44.87	$45.00	$45.00

The Louis Stokes Alliance for Minority Participation – Bridge to the Doctorate (LSAMP-BD)
The LSAMP program assists universities and colleges in diversifying the STEM workforce through their efforts at significantly increasing the number of students successfully completing high quality degree programs in STEM disciplines. Particular emphasis is placed on transforming STEM education through innovative recruitment and retention strategies and experiences in support of groups historically under-represented in STEM disciplines: African-Americans, Alaskan Natives, American Indians, Hispanic Americans, Native Hawaiians, and Native Pacific Islanders.

Established LSAMP Alliances are eligible to apply for Bridge to the Doctorate support. LSAMP-BD funding allows institutions to provide stipend support ($30,000 per year) along with a COE allowance to the institution for tuition, health insurance, and other fees up to $10,500 per year for up to two years of post-baccalaureate study. A plan for connecting a significant number of newly matriculated LSAMP students, including masters degree graduates, to doctoral degree programs is expected.

The NSF Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM) Program
The S-STEM program provides institutions with funds for student scholarships to encourage and enable academically talented U.S. students demonstrating financial need to enter the STEM workforce or STEM graduate school following completion of an associate, baccalaureate, or graduate degree in STEM fields. S-STEM provides individual scholarships of up to $10,000 per year, depending on financial need.

The Robert Noyce Teacher Scholarship Program (NOYCE)
The NOYCE Scholarship Program seeks to encourage talented science, technology, engineering, and mathematics majors and professionals to become K-12 mathematics and science teachers. Through the NOYCE NSF Teaching Fellowship/Master Teaching Fellowship Track, funding is provided to support STEM professionals who enroll as NSF Teaching Fellows in masters degree programs leading to teacher certification by providing academic courses, professional development, and salary supplements while they are fulfilling a four-year teaching commitment in a high-need school district. This track also supports the development of NSF Master Teaching Fellows by providing professional development and salary supplements for exemplary mathematics and science teachers to become Master Teachers while they fulfill a five-year teaching commitment in high-need school districts.

Programs in Support of Graduate Education and Workforce Development
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
LSAMP-BD	$11.84	$17.00	$17.00
S-STEM	1.93	0.30	0.30
NOYCE Teaching and Master Teaching Fellows (10A)	18.49	18.00	22.00
Total	**$32.26**	**$35.30**	**$39.30**

Totals may not add due to rounding.

Evaluation
The evaluation approach to assess the impact of the NSF-wide investment in graduate education will include a variety of components and will be developed in FY 2015 and FY 2016, with plans for a combination of program-specific and thematic evaluation efforts. Key metrics currently under consideration encompass student development (e.g., quality of education and career development, comparing student experiences based on funding mechanism) and career impact (e.g., career trajectories, productivity appropriate for careers, and leadership roles in public and private sectors).

NATIONAL SCIENCE FOUNDATION CENTERS

NSF supports a variety of centers programs that contribute to the Foundation's mission and vision. Centers exploit opportunities in science, engineering, and technology in which the complexity of the research program or the resources needed to solve the problem require the advantages of scope, scale, duration, equipment, facilities, and students. Centers are a principal means by which NSF fosters interdisciplinary research.

NSF Centers
(Dollars in Millions)

	Program Initiation	Number of Centers in FY 2014	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Centers for Analysis & Synthesis	1995	4	$21.55	$20.90	$18.60	-$2.30	-11.0%
Centers for Chemical Innovation	1998	11	35.49	30.51	32.00	1.49	4.9%
Engineering Research Centers	1985	16	70.06	64.50	56.50	-8.00	-12.4%
Materials Centers[1]	1994	24	24.82	56.00	56.00	-	-
Nanoscale Science & Engineering Centers	2001	6	14.43	12.20	8.18	-4.02	-33.0%
Science & Technology Centers	1987	14	58.41	48.42	59.99	11.57	23.9%
Science of Learning Centers[2]	2003	6	19.34	7.01	-	-7.01	-100.0%
Totals		**81**	**$244.11**	**$239.54**	**$231.27**	**-$8.27**	**-3.5%**

Totals may not add due to rounding.

[1] Due to end-of-fiscal year deadlines, $29.81 million in funding for new Materials Center awards was carried over from FY 2014 and obligated in early FY 2015.

[2] The Science of Learning Centers program will sunset in FY 2015, when the last two centers reach the end of their ten-year funding cycles.

Description of Major Changes

Centers for Analysis and Synthesis – BIO

At the FY 2016 Request, three Centers for Analysis and Synthesis are expected to be funded at $18.60 million ($2.30 million below FY 2015 Estimate). These centers are described below.

Funding provided to the University of Maryland College Park for the Socio-Environmental Synthesis Center (SESync) is $6.0 million, equal to the FY 2015 Estimate. This Center uses synthetic approaches to advance the frontiers of scientific understanding of environmental complexity in order to anticipate and manage emerging environmental change impacting many national and global issues, such as water security. This award will undergo renewal review in FY 2015 for FY 2016 funding, so support will be contingent upon a successful review.

Funding for the Plant Science Cyberinfrastructure Collaborative (iPlant) is $9.0 million, a $2.0 million decrease below the FY 2015 Estimate. The iPlant Center is led by scientists at the University of Arizona, the Texas Advanced Computing Center, Cold Spring Harbor Laboratory and University of North Carolina at Wilmington and enables new conceptual advances through integrative, computational thinking to address an evolving array of grand challenges in the plant sciences, including innovative approaches to education, outreach, and the study of social networks. The $2.0 million reduction is part of this center's planned ramp-down as FY 2016 is the penultimate year of its 10 years of funding.

NSF support to the University of Tennessee Knoxville for the National Institute for Mathematical and Biological Synthesis (NIMBioS) is $3.60 million, a $300,000 decrease below the FY 2015 Estimate. This decrease is part of the planned ramp down phase of the center which will have its last year of funding in FY 2017. Funding includes a small contribution from the MPS Division of Mathematical Sciences. At NIMBioS, top researchers from around the world collaborate across disciplinary boundaries to find creative solutions to today's complex biological problems. A major goal of mathematical models and analysis in biology is to provide insight into the complexities arising from the non-linearity and hierarchical nature of biological systems. The education and outreach program focuses on the interface between mathematics and biology and promotes cross-disciplinary approaches to science for learners of all ages.

Centers for Chemical Innovation (CCI) – MPS

The CCI program is designed to address major, long-term fundamental chemical research challenges attracting broad scientific and public interest, as well as to provide a rich environment for education, outreach, and innovation. The CCIs deliver career-shaping educational opportunities for undergraduate and graduate students and for postdoctoral researchers, including collaborative research and mentoring, cross-disciplinary training, international research experiences, entrepreneurial and innovation training, and communication training. Beginning in 2014, two CCIs extended summer research opportunities to military veterans as part of their broadening participation plans.

CCIs are committed to broadening participation and use various strategies including institutional partnerships to meet their goals. The CCI Program supports the CCI Managing Directors Forum and the Education Coordinators Group and held a program-wide meeting in November 2014. The CCI Program is planning a comprehensive program evaluation in FY 2016 - 2017.

The program is currently structured as a two-phase competition. Phase I centers are funded for three years and may compete for larger Phase II awards, which are funded for five years at a level of $4.0 million per year with the opportunity to be renewed for an additional five years, after which they sunset.

Phase I competitions were not held in FY 2013 or FY 2014 and are not planned for FY 2015 or FY 2016. Three Phase I CCIs, funded as standard awards in FY 2012, will be competing for the new FY 2015 Phase II award. There will not be a new competition for Phase II awards in FY 2016, although one existing Phase II award will be under consideration for renewal. The anticipated CCI Phase II portfolio in FY 2016 will include seven continuing awards and up to two awards (new/renewal) from the FY 2015 competition.

In FY 2016 no more than nine Phase II CCIs will be funded at $32.0 million ($1.49 million below FY 2015 Request). Total funding required to support nine CCIs in FY 2016 is $36.0 million. Of this total, $32.0 million is provided in this submission. The remaining $4.0 million will be provided via co-funding and forward funding in previous years.

Engineering Research Centers (ERC) – ENG

NSF's ERCs enable innovation, bridging the energy and intellectual curiosity of university research focused on discovery with real-world engineered systems and technology opportunities through partnerships with industry. These centers also are successful in educating a technology-enabled workforce with hands-on real-world experience. ERCs can be funded for up to ten years if they clear two renewal reviews, one in year-three to determine if they are structured effectively to deliver on program goals, and another in year-six to determine if they are delivering effectively, making an impact, and tackling challenging tasks to warrant further support.

The ERC program periodically commissions external, program-level evaluations to determine the effectiveness of ERC graduates in industry and the benefits of ERC membership to industry and others.[1] This includes the Post-Graduation Status of Engineering Research Centers − 2010 (SciTech Communications). This study, augmented by a recent update, found that of the 35 ERCs that graduated from NSF support after 10 years, 29 (83 percent) are self-sustaining with strong financial support and most ERC features in place.

At FY 2016 Request, 15 ERCs will be funded at $56.50 million ($8.0 million below the FY 2015 Estimate). Decreased support from the FY 2015 Estimate will result in a reduction in the number of centers from 19 to 15 as the program is between competition years in FY 2016. The next class of ERCs will be funded in FY 2017. Funding and numbers of centers include three Nanosystems ERCs that were first supported in FY 2012. This funding level will also allow supplemental funding opportunities creating links with industry and/or other stakeholders to be established or restored within this program.

Materials Centers – MPS

Materials Research Science and Engineering Centers (MRSECs) advance materials research and provide students with an interdisciplinary education, including global experiences. These centers address fundamental research problems of intellectual and strategic importance that will advance U.S. competitiveness and the development of new technologies.

At FY 2016 Request, $56.0 million (no change from the FY 2015 Estimate) will support 21 MRSECs. There are nine continuing awards from the FY 2011 competition, and one new award and eleven (2008 cohort) renewals from the 2014 competition. Three MRSECs were provided phase-out money as a result of the FY 2014 competition. MRSEC competitions are usually held every three years, the latest in FY 2014. Awards are typically $1.60 to $3.60 million per year.

The MRSEC program continues support of the Materials Research Facilities Network (MRFN), which links the instrumentation and subject matter expertise of MRSECs to the larger materials community as well as encourages MRSEC-to-MRSEC collaborations. The MRSEC program also continues to support the interaction of MRSEC Education Coordinators with the NSF Directorate for Education and Human Resources/Division of Research on Learning in Formal and Informal Settings to formulate methodologies for standardizing outreach program assessment and evaluation.

Finally, MRSECs interact with minority serving institutions through the Partnership for Research and Education in Materials (PREM) program. In FY 2015, there will be 14 active PREM awards at NSF, all of which are connected to MRSECs. Awards to eight of the 14 PREMs will expire, so they must compete with new applicants in FY 2015. The total number of PREMs is not expected to significantly change with the FY 2015 competition. MRSECs are encouraged to develop initiatives and/or educational programs to broaden participation. One example is the MRSEC to Harvard University, which, in partnership with Bunker Hill Community College, encourages military veterans to participate in STEM fields.

Nanoscale Science and Engineering Centers (NSEC) – ENG

Nanotechnology, which addresses the smallest of scales, is projected to be one of the largest drivers of technological innovation for the next decade and beyond. This potential was recognized in the National Nanotechnology Initiative (NNI), particularly in the burgeoning area of nanomanufacturing. Research at the nanoscale, through NSF-funded NSECs, aims to advance the development of the ultra-small technology that will transform electronics, materials, medicine, environmental science, and many other fields. Each center has an extended vision for research. Together they provide coherence and a long-term outlook to U.S. nanotechnology research and education and also address the social and ethical

[1] http://erc-assoc.org/content/erc-program-evaluations-and-case-studies-program-impact

implications of such research. NSEC funding supports education and outreach programs from K-12 to the graduate level, which is designed to develop a highly skilled workforce, advance pre-college training, and further public understanding of nanoscale science and engineering. NSECs have strong partnerships with industry, national laboratories, and international centers of excellence, which puts in place the necessary elements to bring discoveries in the laboratory to real-world, marketable innovations and technologies.

The FY 2016 Request is $8.18 million ($4.02 million below the FY 2015 Estimate). This will support two continuing NSECs. The decrease is primarily due to one center receiving the final year of NSF funding in FY 2015. NSEC support will continue to decline as NSECs graduate and transition to Nanosystems Engineering Research Centers (see the Engineering Research Center section above). No new NSEC competitions are planned.

Science and Technology Centers: Integrative Partnerships (STCs) - multi-directorate

The Science and Technology Centers: Integrative Partnerships program advances interdisciplinary discovery and innovation in science and engineering through the integration of cutting-edge research, excellence in education, targeted knowledge transfer, and the development of a diverse workforce. The STC portfolio reflects NSF-supported disciplines. Examples include: understanding the brain; engineering of biological systems; energy-efficient electronics; global and regional environmental systems − sustainability and change; new ways of handling the extraction, manipulation, and exchange of information; cyber security; and new materials for optical and electronic applications. STCs engage the Nation's intellectual talent and collaborate with partners in academia, industry, national laboratories, and government. STCs strengthen the caliber of the Nation's science, technology, engineering, and mathematics workforce through challenging research experiences for students, postdoctoral fellows, researchers, and educators; and advance public scientific understanding through partnerships with K-12 and informal education communities.

The FY 2016 Request of $59.99 million will support eight existing STCs and the administrative costs associated with program management and oversight. Awards range from $4.09 million per year for an award in the 2010 cohort to $5.0 million per year for remaining 2010 and 2013 cohorts. Awards are for five years, with possible renewal for an added five years, or ten years total. In FY 2014, a solicitation for a new STC class was issued to replace the sunsetting 2005/2006 cohort. About 260 proposals were received with the expectation of making four new awards in FY 2016 for a total of $20.0 million.

Estimates for Centers Participation in 2014

	Number of Participating Institutions	Number of Partners	Total FY 2014 NSF Support (in millions)	Total Leveraged Support (in millions)	Number of Participants
Centers for Analysis & Synthesis	1,978	744	$22	$21	12,423
Centers for Chemical Innovation	81	75	$35	$3	741
Engineering Research Centers	719	388	$70	$131	4,863
Materials Centers[1]	394	301	$25	$47	4,512
Nanoscale Science & Engineering Centers	653	590	$14	$44	4,500
Science & Technology Centers	201	218	$58	$38	2,166
Science of Learning Centers	79	102	$19	$34	952

[1] Total FY 2014 NSF Support excludes $29.81 million carried over from FY 2014 to FY 2015.

No. of Participating Institutions: All academic institutions participating in activities at the centers.

No. of Partners: The total number of non-academic participants, including industry, states, and other federal agencies at the centers.

Total Leveraged Support: Funding for centers from sources other than NSF.

Number of Participants: The total number of people who use center facilities, not just persons directly support by NSF.

Centers Supported by NSF in FY 2014

Center	Institution	State
Centers for Analysis and Synthesis		
National Evolutionary Synthesis Center	Duke, NC State U, U of N. Carolina	NC
National Institute for Mathematical & Biological Synthesis	U of Tennessee	TN
Plant Science Cyberinfrastructure Collaborative	U of Arizona	AZ
SocioEnvironmental Synthesis Center	U of Maryland	MD
Centers for Chemical Innovation		
CCI Solar Fuels (phase II)	California Institute of Tech	CA
Center for Aerosol Impacts on Climate and Environment (phase I)	U of California-San Diego	CA
Center for Chemical Evolution (phase II)	Georgia Institute of Tech	GA
Center for Enabling New Technologies through Catalysis (phase II)	U of Washington	WA
Center for Selective C-H Functionalization (phase II)	Emory	GA
Center for Sustainable Materials Chemistry (phase II)	Oregon State	OH
Center for Sustainable Nanotechnology (phase I)	U of Wisconsin	WI
Center for Sustainable Polymers (phase I)	U of Minnesota-Twin Cities	MN
Center for Sustainable Renewable Feedstocks (phase I)	U of California-Santa Barbara	CA
Chemistry at the Space-Time Limit (phase II)	U of California-Irvine	CA
CO^2 as a Sustainable Feedstock for Chemical Commodities (phase I)	Brown	RI
Engineering Research Centers		
Advanced Self-Powered Systems of Integrated Sensors and Technologies	North Carolina State U	NC
Biorenewable Chemicals	Iowa State	IA
Center for Ultra-wide-area Resilient Electric Energy Transmission Network (CURENT)	U of Tennessee	TN
Compact and Efficient Fluid Power	U of Minnesota	MN
Future Renewable Electric Energy Delivery and Management Systems	North Carolina State	NC
Integrated Access Networks	U of Arizona	AZ
Mid-Infrared Technologies for Health and the Environment	Princeton	NJ
Nanomanufacturing Systems for Mobile Computing and Mobile Energy Technologies	University of Texas-Austin	TX
Quantum Energy and Sustainable Solar Technologies (QESST)	Arizona State	AZ
Re-inventing the Nation's Urban Water Infrastructure	Stanford	CA
Revolutionizing Metallic Biomaterials	North Carolina A&T U	NC
Sensorimotor Neural Engineering	U of Washington	WA
Smart Lighting	Rensselaer Polytechnic Institute	NY
Structured Organic Particulate Systems	Rutgers	NJ
Synthetic Biology	U of California-Berkeley	CA
Translational Applications of Nanoscale Multiferroic Systems	U of California-Los Angeles	CA
Materials Centers		
Brandeis Materials Research Science and Engineering Center	Brandeis	MA
Columbia University Materials Research Science and Engineering Center[2]	Columbia	NY
Center for Emergent Materials	Ohio State	OH
Cornell Center for Materials Research	Cornell	NY
Center for Materials Science and Engineering	Massachusetts Institute of Tech	MA
Center for Multifunctional Nanoscale Materials Structures	Northwestern	IL
Quantum and Spin Phenomena in Nanomagnetic Structures	U of Nebraska	NE
Center for Nanoscale Science	Pennsylvania State	PA
Center for Nanostructured Interfaces	U of Wisconsin	WI
Center for Interface Structures and Phenomena	Yale	CT

[2] This Materials Center was given a no-cost extension to its award in FY 2014 but received no additional funding.

Center for Photonics and Multiscale Nanomaterials	U of Michigan	MI
Liquid Crystals Materials Research Center	U of Colorado	CO
Laboratory for Research on the Structure of Matter	U of Pennsylvania	PA
Materials Research Center	U of Chicago	IL
Materials Research Science and Engineering Center	Harvard	MA
Materials Research Science and Engineering Center	Georgia Institute of Tech	GA
Materials Research Science and Engineering Center	New York U	NY
Materials Research Science and Engineering Center	U of California-Santa Barbara	CA
Materials Research Science and Engineering Center	U of Minnesota	MN
Materials Research Science and Engineering Center	U of Utah	UT
Materials Research Science and Engineering Center on Polymers	U of Massachusetts-Amherst	MA
Princeton Center for Complex Materials	Princeton	NJ
Renewable Energy Materials Science and Engineering Center	Colorado School of Mines	CO
Triangle Materials Research Science and Engineering Center	Duke	NC
Nanoscale Science and Engineering Centers		
Affordable Nanoengineering of Polymer Biomedical Devices	Ohio State	OH
Center for Environmental Implications of Nanotechnology (CEIN)	Duke	NC
Nanotechnology in Society Network: Center at ASU	Arizona State U	AZ
Nanotechnology in Society Network: Center at UCSB	U of California-Santa Barbara	CA
National Nanomanufacturing Network: Center for Hierarchical Manufacturing	U of Massachusetts-Amherst	MA
Predictive Toxicology Assessment & Safe Implementation of Nanotechnology in the Environment (CEIN)	U of California-Los Angeles	CA
Science and Technology Centers		
BEACON: An NSF Center for the Study of Evolution in Action	Michigan State U	MI
Biology with X-Ray Lasers	SUNY Buffalo	NY
Center for Brains, Minds, and Machines: The Science and the Technology of Intelligence	Massachusetts Institute of Tech	MA
Center for Coastal Margin Observation and Prediction	Oregon Health and Science U	OR
Center for Dark Energy Biosphere Investigations	U of Southern California	CA
Center for Energy Efficient Electronics Science	U of California-Berkeley	CA
Center for Integrated Quantum Materials	Harvard	MA
Center for Layered Polymeric Systems	Case Western Reserve	OH
Center for Microbial Oceanography: Research and Education	U of Hawaii-Manoa	HI
Center for Multi-Scale Modeling of Atmospheric Processes	Colorado State	CO
Center for Remote Sensing of Ice Sheets	U of Kansas	KS
Emergent Behaviors of Integrated Cellular Systems	Massachusetts Institute of Tech	MA
Emerging Frontiers of Science Information	Purdue	IN
Team for Research in Ubiquitous Secure Technology	U of California-Berkeley	CA
Science of Learning Centers		
Center for Excellence for Learning in Education, Science, and Technology	Boston U	MA
Pittsburgh Science of Learning Center - Studying Robust Learning with Learning Experiments in Real Classrooms	Carnegie Mellon	PA
LIFE Center - Learning in Formal and Informal Environments	U of Washington	WA
Spatial Intelligence and Learning Center	Temple	PA
The Temporal Dynamics of Learning Center	U of California-San Diego	CA
Visual Language and Visual Learning	Gallaudet	DC

NSF EVALUATION AND ASSESSMENT CAPABILITY $8,860,000
+$3,360,000 / 61.1%

Overview
The objective of this initiative is to provide NSF with the capacity to operate from a basis of evidence in policy decisions. The Evaluation and Assessment Capability (EAC) will provide centralized support and resources for data collection, analytics, and the design of evaluation studies and surveys. These activities will enable NSF to more consistently evaluate the impacts of its investments, to make more data-driven decisions, and to establish a culture of evidence-based planning and policy-making.

Goals
The leadership, expertise, and resources of EAC will enable the accomplishment of the following multi-year goals:

Goal 1. Encourage a culture of evidence-based planning and policy making that routinely articulates program goals, milestones, and metrics.

Goal 2. Enable consistent evaluation of the impact of NSF investments with a high degree of rigor and independence.

Goal 3. Develop and implement a coordinated framework for evaluating NSF-wide investments that is consistent with agency strategic and performance plans.

Goal 4. Increase access to program-level post-award outcome data to support decision making and evaluation designs through stronger data analytics, business intelligence, and visualization tools.

Approach
Over the FY 2014 - FY 2018 period, NSF will establish mechanisms for Foundation-wide leadership and coordination in program evaluation; provide expert support and resources for data collection, integration, and management; and improve directorate/office evaluation capacity. A leader of the EAC, as well as additional staff, will be in place in FY 2015.

Investment Framework

Evaluation and Assessment Capability Funding

(Dollars in Millions)

FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
$0.80	**$5.50**	**$8.86**

FY 2014 – FY 2015
Specific Investment 1: Investments in communications, training, and portfolio analysis tool development to support rigorous evaluation planning, portfolio analysis, and the use of evidence and data for programmatic decision making are planned.

- In FY 2014, an NSF-wide Portfolio Analysis Taskforce was convened with different areas of relevant expertise across the foundation being represented. A needs assessment survey was conducted and NSF-wide portfolio analysis needs were identified.
- In FY 2015, the report from the Portfolio Analysis Taskforce will be discussed and relevant recommendations will form the basis for the portfolio analysis tools system requirements.

Specific Investment 2: The EAC will conduct high-impact evaluations for cross-cutting high visibility programs, and programs whose strategic reviews have revealed a need for rigorous evaluation. The EAC will also coordinate with the National Center for Science and Engineering Statistics (NCSES) on the design of data collection instruments and methodological considerations for longitudinal data collections.

- In FY 2014, a report from the NSF Innovation Corps (I-Corps™) feasibility study was received. This report informed leadership of the additional data collection necessary to rigorously evaluate the impact of the program. The EAC initiated the following program evaluation efforts: program evaluations for Integrated NSF Support Promoting Interdisciplinary Research and Education (INSPIRE) and Science Engineering, and Education for Sustainability (SEES).
- In FY 2015, progress reports from SEES evaluation and final actionable report for INSPIRE are expected. Based on the FY 2014 feasibility study for I-Corps™, a longitudinal data collection and formal evaluation study will be launched to evaluate the impact of the I-Corps™ program. A longitudinal data collection for the Graduate Research Fellowship Program (GRF) will be initiated.

Specific Investment 3: The EAC will develop and implement a coordinated evaluation framework.

- In FY 2014, the EAC identified consultants for a workshop to explore the frontier in evaluation of research investments to inform a framework that establishes levels of evidence and rigor for different types of programs, including basic research programs. The EAC piloted a peer review mechanism for statements of work and evaluation designs against evaluation quality principles.
- In FY 2015, in consultation with advisory groups, the EAC will begin to define NSF's evaluation and assessment quality principles and an evaluation policy for the agency.

FY 2016 Request

- Building on the prior year Specific Investment 1 activities, the EAC will finalize system requirements and begin development of a portfolio analysis tools system.
- Specific Investment 2 will continue through the following activities:
  - The EAC will implement a system to monitor GRF fellows on a longitudinal basis over their careers based on the lessons learned during the FY 2014 – FY 2015 pilot study.
  - A cross-cutting evaluation will be initiated for NSF investments in broadening participation on the following populations:
    - underrepresented undergraduate and graduate students,
    - underrepresented faculty in STEM departments,
    - underrepresented principal investigators submitting proposals worthy of support, and
    - underrepresented institutions.

    The evaluation design will use a mixed methods approach (qualitative and quantitative) to do a formative assessment of what mechanisms work best and a summative evaluation of the impact of NSF's historic investments in broadening participation.
- The impact achieved by different funding mechanisms used to identify and fund interdisciplinary and potentially transformative research (IDR and PTR) at NSF, including core programs, will be evaluated.
- The quality of the proposal responses to the revised elements of the broader impacts criterion and the actual consecution of those funded activities will be assessed.
- The EAC will develop a study to explore the cumulative longitudinal impact of NSF funding on individuals, (their career paths, creative ability, mentoring of students, networks, and other spillover effects such as single investigators, Research Experiences for Undergraduates (REUs), fellows, etc.).
- The EAC will initiate planning for the formative and summative evaluation of NSF strategic investments associated with NSF priority research areas (e.g. Innovations at the Nexus of Food, Energy, and Water Systems, Understanding the Brain)

- Under Specific Investment 3, the EAC will convene a workshop with methodological leaders from other disciplines (econometrics, for example) to explore the adaptation of methods used in other realms to the evaluation of fundamental or basic scientific research, building on what we have learned about evaluating these types of programs and further defining assessment quality principles and an evaluation policy for the agency.

FY 2017 – FY 2018

In FY 2017 and FY 2018 investments in the three specific areas will continue. The EAC will finalize the development of a portfolio analysis system and start using the tools consistently. Evaluation studies will be initiated for broadening participation, interdisciplinary research programs, large facilities, and broader impacts and their cumulative impact on people. The EAC staff, the EAC working group, and the EAC steering committee will attend a focused discussion/retreat to get expert advice on methodological issues encountered evaluating science investment programs that could be solved by extrapolating from other disciplines. A formative review of the Evaluation Framework will be scheduled based on the quality of evaluation reports and usefulness of the findings.

PROPOSAL MANAGEMENT EFFICIENCIES $8,650,000
-$470,000 / -5.2%

Overview

The merit review process is one of NSF's critical business functions. Effective merit review recognizes high-quality research, including high-risk, high-reward or potentially transformative ideas, empowers NSF to support such proposals, and retains the confidence and trust of NSF's external stakeholders. NSF's current approach to merit review relies on NSF staff making funding recommendations advised by *ad hoc* (mail) and panel review. This process is time- and resource-intensive.

NSF's merit review process faces extraordinary pressures as proposal numbers grow and success rates decline. Competition for funding has increased significantly. Between FY 1999 and FY 2013, the number of full and preliminary proposals evaluated increased by 79 percent, and funding rates dropped from 32 percent to 22 percent.[1] Additionally, workload has increased for researchers, reviewers, and NSF staff. These systemic stresses may be prompting some researchers to submit fewer innovative ideas. The workload of panel reviewers and the travel time involved means that some experts are reluctant or unable to serve on review panels held at NSF. The growth in the number of review panels led to a steady growth of nine percent per year, between FY 2007 and FY 2011, in NSF's travel-related obligations. In FY 2011, the combined cost to NSF of proposal review panel compensation and travel, was over $36 million.[2] Through the implementation of expanded use of virtual panels and increased use of non-refundable tickets, this was reduced to under $24 million in FY 2013. To mitigate some of the stresses on NSF's merit review system, a number of critical investments, described below, have been identified.

Goal

The goals of NSF's Proposal Management Efficiencies activities are:

1. Reduce the amount of staff time, per proposal, required to conduct merit review;
2. Reduce the average time burden placed on individual reviewers;
3. Reduce the per-proposal cost of the review process;
4. Increase the number of qualified individuals who participate in the review process; and
5. Improve the ability of institutions to submit successful proposals.

Total Funding for Proposal Management Efficiencies
(Dollars in Millions)

FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
$2.53	**$9.12**	**$8.65**

Approach

An NSF-wide working group examined the merit review processes used by other research funding agencies, discussed the benefits and drawbacks of different possible approaches with researchers and university administrators on numerous NSF Advisory Committees, talked with reviewers, and consulted with the National Science Board (NSB). Based on this, NSF determined that significant improvements in workload and cost could be achieved. In addition, NSF determined that the aging technologies that NSF

[1] In FY 1999, 29,957 full or preliminary proposals were competitively reviewed; in FY 2013, the number was 53,690. Sources: Reports to the National Science Board on NSF's Merit Review Process, FYs 2001 (NSB 02-21, www.nsf.gov/nsb/documents/2002/nsb0221/nsb0221.pdf - for FY 1999 data) and 2013 (NSB 14-32, www.nsf.gov/nsb/publications/2014/nsb1432.pdf).

[2] When other direct costs to NSF of holding face-to-face panels, excluding salary, are added, the total cost was approximately $38 million.

uses to support its merit review processes constitute a risk to one of NSF's critical lines of business. A plan was developed to invest in information and communications technology, personnel, and increased use of automation, training, and outreach to institutions. The principal components of this plan are:

- Virtual Meeting Technologies: Provision of personnel and infrastructure to support much greater use of virtual meeting technologies for review panels. This supports Goals 2, 3, and 4.
- Technological Support for Proposal and Review Management: Deployment of a more capable infrastructure to support the identification, selection, and recruitment of reviewers, to manage the receipt of reviews, to increase automation of the preliminary processing of proposals for compliance to standards, and to provide tools for portfolio management. This supports Goals 1, 4, and 5.
- Demand Management: Outreach to individual institutions to help increase proposal success rates and reduce the submission of non-competitive proposals. This supports Goal 5.

The efforts to improve further NSF's merit review process are undertaken by staff in the program directorates, the Office of Integrative Activities, the Office of Information and Resource Management, and the Office of Budget, Finance, and Award Management.

Virtual Meeting Technologies

The predominant review method used has become the review panel, convened at NSF, where a set of experts assemble to evaluate proposals. The travel costs associated with review panels are a budget burden. Beginning in FY 2012, NSF has experimented with increasing its use of virtual meeting technologies to hold synchronous review panels. Methods have included teleconferences, commercial video-conferencing technologies, and "virtual world" software. This investment continues NSF's expanded use of virtual review panels and will restrain the panel costs, broaden the range of reviewers participating in panels, and reduce the average workload of individual reviewers.

Technological Support for Proposal and Review Management

In the prior year's request, this investment was divided into two separate items, one focusing on reviews and reviewers and one focused on proposals. Here they are combined to better reflect the way in which this effort is managed internally. This multi-year investment aims: to reduce the NSF staff time used in identifying potential reviewers and communicating with reviewers; to improve the return rate for *ad hoc* reviews; to automate more of the checks for compliance with proposal preparation requirements; to modernize pre-award and proposal submission capabilities; and to provide more advanced capabilities to support portfolio management. The FY 2016 investment will continue work begun in FY 2015 to replace outdated and expensive client-server technology with modern, web-based technology and to modernize pre-award and proposal submission capabilities to provide workload efficiencies to NSF staff and the research community.

Demand Management

The rate at which submitted proposals to NSF are funded varies widely between institutions. Reducing this variation would improve the workloads of reviewers and NSF staff. NSF will continue a program of enhanced outreach that is tailored to individual institutions. The outreach will include web-based information sharing and direct dialogue. The outreach will propagate best practices; encourage networking between institutions; and improve the flow of ideas between NSF and the research community. The potential return on investment for NSF is significant; even a one percent reduction in overall proposal pressure corresponds to a reduction in staff workload that is similar to adding five or six new staff members. There are also benefits for the institutions. Reductions in the number of proposals that institutions must submit to support their faculty members' research programs benefits both their faculty and staff.

Investment Framework

Proposal Management Efficiencies Funding Estimates

(Dollars in Millions)

Activity	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
Virtual Meeting Technologies	$2.23	$0.10	$0.10
Technological Support for Proposal and Review Management	-	8.72	8.25
Assessment of Impact of Pilot Activities	0.30	0.30	0.30
Total	**$2.53**	**$9.12**	**$8.65**

Totals may not add due to rounding.

FY 2014 – FY 2015

Virtual Meeting Technologies

In the years prior to FY 2014, NSF initiated an assessment of several technological and organizational approaches to virtual meetings, began developing training modules for NSF staff and reviewers, and conducted a medium-scale pilot activity in which virtual panels were conducted primarily with a specific virtual meeting platform, and conducted a smaller scale pilot activity using asynchronous virtual panel technology. In FY 2014 and FY 2015, the virtual panel pilot is continuing at an expanded scale with a FY 2015 target that at least 33 percent of panels be conducted as virtual panels. Alternative virtual meeting platforms are being piloted. An alternative approach to asynchronous virtual panels is being tested.

Technological Support for Proposal and Review Management

This investment comprises improvements in those parts of NSF's IT systems used to conduct the merit review process. Planning for a more robust business rules system to support proposal processing was conducted in FY 2014. In FY 2015, an initial implementation of a system to check requirements that apply to all NSF proposals is being rolled out and NSF will begin requirements definition, development, and initial testing of a more sophisticated automated proposal compliance checking system that can implement program-specific requirements. In FY 2015, NSF is beginning the migration of merit review applications built on aging unstable client-server technology to modern web-based technology. This includes those that support merit reviews of NSF proposals and management of reviewers. The initial focus is to migrate systems used to set up and conduct panels. This will increase the reliability of these mission-critical applications, provide workload efficiencies to staff, and make it easier to make changes to systems to respond to emerging NSF business needs.

Demand Management

A pilot activity involving outreach to a small number of research institutions was conducted in late FY 2013 and in early FY 2014. In FY 2015, an access-controlled web-portal has been developed to support the outreach. Continuation of the pilot has been postponed until later in FY 2015. In the second half of FY 2015, planning is anticipated for more demand management activities in FY 2016.

FY 2016 Request

Virtual Meeting Technologies
Support for virtual panels will continue with a target of at least 40 percent of panels being conducted as virtual panels. Guidelines and procedures for virtual panel use will be standardized based on the results of the preceding multi-year pilot activity. Improved virtual meeting technology will be used as new tools become available. Per diem compensation for individuals participating virtually in NSF meetings, including virtual panelists, will be decreased from the current $280 per day to a new level of $200 per day.

Technological Support for Proposal and Review Management
NSF will continue migrating merit review applications built on aging unstable client server technology to modern web-based technology and make additional enhancements to NSF's eBusiness systems informed by the results of ongoing pilot activities. NSF will continue to modernize pre-award and proposal submission capabilities to provide workload efficiencies to NSF staff and the research community. This includes continued work on an automated proposal compliance checking system that can implement program-specific requirements.

Demand Management
NSF will continue to refine and implement its demand management activities.

FY 2017 – FY 2018

Virtual Meeting Technologies
In FY 2017 and beyond, the use of virtual panels will be a standard component of NSF's merit review process. Improved virtual meeting technology will continue to be used as new tools become available.

Technological Support for Proposal and Review Management
NSF will continue migrating merit review applications built on aging unstable client server technology to modern web-based technology. NSF will continue to modernize pre-award and proposal submission capabilities to provide workload efficiencies to NSF staff and the research community. This includes the completion of work on an automated proposal compliance checking system that can implement program-specific requirements. A new researcher database (principal investigators and reviewers) will be developed with researcher self-registration capability and tools for identifying potential reviewers. NSF's eBusiness systems will be extended to include a component that tracks review requests and responses, and that automatically sends reminders about outstanding requests to reviewers and NSF staff. Advanced proposal data management capabilities to support portfolio management will be deployed.

Demand Management
NSF will continue to refine and implement its demand management activities.

Evaluation Framework
To support evaluation of the impacts of the pilots and to identify further potential to enhance the merit review process, in FY 2014 NSF engaged a contractor to develop and conduct surveys of NSF reviewers, investigators, and program officers to assess workload, the technologies used to support merit review, and the quality of feedback provided to proposers. The surveys will collect ancillary data so that statistical analysis will be able to separate the impacts of merit review core and pilot activities from the effects of the research domain to which the proposals and reviewers belong, the type of home institution, and basic demographic data variables. Surveys will be conducted in late FY 2015 and FY 2016. The resulting data will be made available to programs considering using the approaches that have been piloted or considering modifications to their existing approaches to merit review to inform their choices.

SELECTED CROSSCUTTING PROGRAMS

Many investments at NSF draw on interdisciplinary teams from across the Foundation and are supported by multiple directorates. Other parts of this chapter, NSF-Wide Investments, provide narratives for NSF-wide priority investments such as Cyber-enabled Materials, Manufacturing, and Smart Systems (CEMMSS); Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS); and Understanding the Brain (UtB). Additional cross-cutting programs at NSF are presented in the narrative below, and full funding data for these programs is provided in the Summary Tables chapter.

ADVANCE
In FY 2016, ADVANCE will fund transformative efforts to address the systemic barriers to women's full participation in academic science, technology, engineering, and mathematics (STEM) careers with funding of $14.90 million, unchanged from the FY 2015 Estimate. A major focus in FY 2016 will be broadening the spectrum of institutions participating in the program to include more undergraduate and minority serving institutions and community colleges. This focus aims to increase the participation and advancement of women across higher education in academic science and engineering careers. Funding support for ADVANCE in FY 2016 is provided by the Directorates for Biological Sciences (BIO); Computer and Information Science and Engineering (CISE); Education and Human Resources (EHR); Engineering (ENG); Geosciences (GEO); Mathematical and Physical Sciences (MPS); and Social, Behavioral, and Economic Sciences (SBE).

Cultivating Cultures for Ethical STEM (CCE STEM)
NSF's FY 2016 Request provides $1.90 million for CCE STEM, $640,000 below the FY 2015 Estimate. The CCE STEM program fosters ethical STEM research in all of the fields of science and engineering that NSF supports, including within interdisciplinary, inter-institutional, and international contexts. CCE STEM research projects use basic research to produce knowledge about what constitutes responsible or irresponsible, just or unjust scientific practices and sociotechnical systems, and how to best instill students with this knowledge. This program builds on NSF's prior support for ethics-related research and program development, most recently Ethics Education in Science and Engineering. Funding for CCE STEM is provided by CISE, ENG, GEO, SBE, and Integrative Activities (IA).

Enhancing Access to the Radio Spectrum (EARS)
NSF's FY 2016 Request provides $21.0 million for EARS, a decrease of $2.0 million from the FY 2015 Estimate. EARS' purpose is to fund interdisciplinary research that can enhance the efficiency with which radio spectrum is used, and/or lead to improved access to wireless services for all Americans. The EARS program is responsive to the 2010 NSF-supported workshop report, *Enhanced Access to the Radio Spectrum: A Path Forward*,[1] and to the 2010 National Research Council report, *Spectrum Management for Science in the 21st Century*.[2] Both of these reports highlighted the need for research on new and innovative ways to utilize the spectrum more efficiently. EARS is a collaboration among CISE, ENG, and MPS.

Faculty Early Career Development (CAREER)
The FY 2016 Request provides $232.49 million for the CAREER program, an increase of $9.61 million over the FY 2015 Estimate. This will support approximately 400 new CAREER awards, which support exceptionally promising college and university junior faculty who are committed to the integration of research and education and who are most likely to become the leaders in their fields. All R&RA directorates participate in the CAREER program.

[1] www.nsf.gov/mps/ast/nsf_ears_workshop_2010_final_report.pdf
[2] www.nap.edu/openbook.php?record_id=12800

Integrated NSF Support Promoting Interdisciplinary Research and Education (INSPIRE)
The FY 2016 Request includes $28.05 million for INSPIRE, unchanged from the FY 2015 Estimate. INSPIRE was established in FY 2012 to encourage and support bold, potentially transformative (PTR) interdisciplinary research (IDR) that transcends typical programmatic scope. It responds to issues raised in a variety of external and internal publications, including National Academies[3] and National Science Board[4] reports and documents relating to the America COMPETES Reauthorization Act of 2010. These reports identified barriers to interdisciplinary research and discussed perceptions in the research community that NSF does not always provide adequate opportunities for unsolicited PTR/IDR proposals that cross traditional boundaries. INSPIRE provides NSF with a funding mechanism that addresses the FY 2012 PCAST[5] recommendations to adopt a diverse set of mechanisms to optimize a portfolio of awards that includes projects with significant impact and that fall outside of traditional disciplines. In FY 2016, INSPIRE will support approximately 25 new up-to-$1.0-million awards. Additionally, NSF will investigate opportunities for interagency partnerships. All directorates participate in INSPIRE, with additional funding provided through the IA budget line.

Long-Term Ecological Research (LTER)
The FY 2016 Request provides $27.95 million, an increase of $360,000 above the FY 2015 Estimate. LTER supports fundamental ecological research that requires data collection over long time periods and often at large spatial scales. This program supports a loosely coordinated network of more than two dozen field sites that focus on: 1) understanding ecological phenomena that occur over long temporal and broad spatial scales; 2) creating a legacy of well-designed, long-term ecological experiments; 3) conducting major syntheses and theoretical efforts; and 4) providing information to identify and to address environmental problems. LTER projects represent a diversity of habitats in continental North America, the Caribbean, Pacific Ocean, and the Antarctic, including coral reefs, arid grasslands, estuaries, lakes, prairies, forests, alpine and Arctic tundra, urban areas, and agroecosystems. The increased support for LTER in FY 2016 will be used to stimulate new research activities, such as examining evolutionary change in populations and communities that have been studied for over 30 years and syntheses of long-term data using contemporary modeling methods. Funding for LTER is provided by BIO, GEO, and SBE.

National Ecological Observatory Network (NEON) infrastructure will be co-located at eleven LTER sites. NEON is a continental-scale infrastructure facility providing standardized physical and data resources to researchers and educators. LTER is a network of long-term research projects aimed at understanding ecological processes in a wide range of ecosystems. Ongoing research at LTER sites may take advantage of data generated using NEON infrastructure. In addition, the co-location of NEON infrastructure at LTER sites will stimulate new research that builds on the long history of LTER research by enhancing the ability to extend site-based knowledge to regional and continental scales. For more information on NEON, see the NEON narrative in the Major Research Equipment and Facilities Construction chapter.

[3] Committee on Facilitating Interdisciplinary Research, Committee on Science, Engineering, and Public Policy (2004). *Facilitating interdisciplinary research.* National Academies. Washington: National Academy Press.
[4]Enhancing Support of Transformative Research at the National Science Foundation www.nsf.gov/nsb/documents/2007/tr_report.pdf
[5] President's Council of Advisors on Science and Technology, *Transformation and Opportunity: The Future of the U.S. Research Enterprise,* www.whitehouse.gov/sites/default/files/microsites/ostp/pcast_future_research_enterprise_20121130.pdf (2012).

Research Experiences for Undergraduates (REU)
In FY 2016, $77.60 million in funding is requested for the REU Sites and Supplements program, an increase of $4.40 million above the FY 2015 Estimate. NSF's ongoing support for REU reflects the importance of undergraduate research experiences in building students' interest and competence in STEM disciplines, and aligns with the Administration's focus on improving undergraduate STEM education. REU grants involve students at all stages of undergraduate education. REU Supplements allow students to join research projects that are supported by NSF research grants. REU Sites support cohorts of students to conduct research within STEM disciplines or on topics that cut across disciplines. Most of the students in an REU Site come from outside the host institution. This feature enables the program to involve students in research who might not otherwise have the opportunity, particularly students from institutions where research activities are limited. The REU program encourages partnerships between community colleges and baccalaureate degree-granting institutions to provide research opportunities for community college STEM students and faculty. Starting in FY 2015, NSF's REU Sites and Supplements programs fall within the IUSE purview, with budget and award decisions remaining within individual directorates. Funding for REU is provided by BIO, CISE, ENG, GEO, MPS, and SBE.

Research in Undergraduate Institutions (RUI)
The FY 2016 Request for NSF's RUI program totals $39.15 million, or $450,000 below the FY 2015 Estimate. The RUI activity supports research by faculty members of predominantly undergraduate institutions through the funding of 1) individual and collaborative research projects, 2) the purchase of shared-use research instrumentation, and 3) Research Opportunity Awards for work with NSF-supported investigators at other institutions. Funding for RUI is provided by BIO, CISE, GEO, MPS, and SBE.

NATIONAL NANOTECHNOLOGY INITIATIVE (NNI)

Total Funding for NNI
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
Biological Sciences	$50.28	$48.80	$48.80
Computer and Information Science and Engineering	13.23	13.66	14.14
Education and Human Resources	2.50	2.50	2.50
Engineering	204.76	166.00	168.50
Geosciences	0.30	0.30	0.30
Mathematical and Physical Sciences	191.70	180.62	180.62
Social, Behavioral, and Economic Sciences	1.67	1.40	1.40
Office of International Science and Engineering	0.10	0.10	0.10
Total, NNI	**$464.54**	**$413.38**	**$416.36**

Totals may not add due to rounding.

NSF's contribution to the multiagency National Nanotechnology Initiative (NNI) encompasses the systematic understanding, organization, manipulation, and control of matter at the atomic, molecular, and supramolecular levels in the size range of about 1 to 100 nanometers. Novel materials, devices, and systems – with their building blocks designed on the scale of nanometers – open up new directions in science, engineering, and technology with potentially profound implications for society. With the capacity to control and manipulate matter at this scale, science, engineering, and technology researchers are realizing revolutionary advances in areas such as order-of-magnitude faster computers with less energy consumption; catalysts for industry; molecular medicine; nanosensors to monitor health and environment; efficient and large scale nanomanufacturing of nanotechnology-based products; more resilient materials and system architectures; and sustainable development for water, energy, and food resources utilization. NSF contributes to the NNI goals and five Program Component Areas (PCAs) outlined in the 2014 NNI Strategic Plan and the NNI Supplement to the President's Budget for Fiscal Year 2016.[1] Funding by PCA is shown at the end of this chapter.

FY 2016 NNI Funding

NSF supports nanoscale science and engineering throughout all the research and education directorates as a means to advance discovery, invention, and innovation and to integrate various fields of research. NNI enables increased interdisciplinarity at atomic and molecular levels for about 6,000 active awards with full or partial contents on nanoscale science and engineering (NSE). About 10,000 students and teachers will be educated and trained in NSE in FY 2016.

Overall, total NNI funding in the FY 2016 Request of $416.36 million is $2.98 million over the FY 2015 Estimate of $413.38 million and a decrease of $48.18 million from the FY 2014 Actual of $464.54 million. The decrease is caused in part by the results of the peer review process of unsolicited proposals that resulted in a larger number of highly-ranked nanotechnology projects funded in FY 2014 as compared to what initially was planned.

Several new directions planned for FY 2016 are nanotechnology for water-energy-food processes, nanomodular materials and systems by design including two-dimensional nanoscale materials, and

[1] www.nano.gov

emerging aspects of nanoelectronics and photonics. NSF sponsors an annual NSE grantee conference to assess the progress in nanotechnology and facilitate identification of new research directions.

Partnerships of new NERCs with small businesses in the areas of nanomanufacturing and commercialization will be strengthened while maintaining about the same level of NSF investment. In FY 2016, NSF continues its contributions to translational innovation programs, including Grant Opportunities for Academic Liaison with Industry (GOALI); Industry/University Cooperative Research Centers (I/UCRC); the NSF Innovation Corps (I-Corps™) program; and the two subcomponents of Partnerships for Innovation (PFI) – Accelerating Innovation Research (AIR) and Building Innovation Capacity (BIC). An increased focus is on support of convergence research and education activities in confluence with other priority areas such as: Science, Engineering, and Education for Sustainability/Sustainable Chemistry, Engineering and Materials (SusChEM); Research at the Interface of Biological, Mathematical and Physical Sciences, and Engineering (BioMaPS); and Smart Systems. The NSF Small Business Innovation Research (SBIR) program has an ongoing nanotechnology topic with subtopics for nanomaterials, nanomanufacturing, nanoelectronics and active nanostructures, nanotechnology for biological and medical applications, and instrumentation for nanotechnology.

NSF sponsored an international study on long-term research entitled *Nanotechnology Research Directions for Societal Needs in 2020*.[2] It provides an assessment of nanotechnology development in the last ten years (2000-2010) and a long-term vision of the field in the next decade (2010-2020). This study evaluates the outcomes as recommended by the first report issued in 1999, *Nanotechnology Research Directions: A vision for the next decade*, adopted as an official document of the National Science and Technology Council (NSTC). NSF co-sponsored, with five other NNI agencies, the study entitled *Converging Knowledge, Technology, and Society*[3] evaluating the convergence of nanotechnology with other emerging areas. A study on *Nanomodular Materials and Systems by Design* to identify international activities and research directions will be completed in 2015-2016.[4]

Nanotechnology Signature Initiatives (NSIs)

The first PCA, which encompasses the five Nanotechnology Signature Initiatives (NSIs), will increase by $3.50 million, as compared to the FY 2015 Estimate, to $118.07 million. The changes are in the Sustainable Nanomanufacturing NSI with an increase of $3.0 million for research on breakthrough materials and advanced manufacturing, and in the Nanotechnology for Knowledge Infrastructure NSI, with an increase of $500,000 for nanoinformatics in core programs, dedicated networks, and as part of the Cyber-Enabled Materials, Manufacturing, and Smart Systems (CEMMSS) NSF-wide investment. Three Nanosystems Engineering Research Centers (NERC) are being supported, with a total estimated budget of approximately $55.0 million for five years 2012-2017. Special emphasis will be on:

- Nanotechnology for Solar Energy Collection and Conversion ($27.67 million) – Enhancing understanding of energy conversion and storage phenomena at the nanoscale, and utilization of the unique physical phenomena that occur on the nanoscale to help overcome current performance barriers and substantially improve the collection and conversion of solar energy. This initiative is aimed at using nanotechnology to help overcome current performance barriers and substantially improve the collection and conversion of solar energy.
- Sustainable Nanomanufacturing ($26.40 million) – Establishing manufacturing technologies for economical and sustainable integration of nanoscale building blocks into complex, large-scale systems by supporting product, tool, and process design informed by and adhering to the overall constraints of safety, sustainability, and scalability. This signature initiative specifically focuses on high-performance structural carbon-based nanomaterials, optical metamaterials, and cellulosic

[2] NSF/WTEC 2010, Springer, available on www.nsf.gov/nano and www.wtec.org/nano2/
[3] NSF/WTEC 2013, Springer, available on www.nsf/gov/nano and www.wtec.org/NBIC2-Report/
[4] www.wtec.org/nmsd

nanomaterials. This initiative will establish manufacturing technologies for economical and sustainable integration of nanoscale building blocks into complex, large-scale systems. A program solicitation on Scalable Nanomanufacturing will be announced in FY 2015 and FY 2016.

- Nanoelectronics for 2020 and Beyond ($37.50 million) – Discovery and use of novel nanoscale fabrication processes and innovative concepts to produce revolutionary materials, devices, systems, and architectures to advance the field of nanoelectronics. This initiative is aimed at discovering and using novel nanoscale fabrication processes and innovative concepts to produce revolutionary materials, devices, systems, and architectures to advance the field of electronics. Collaboration in the Nanoelectronics Research Initiative with Semiconductor Research Corporation and the National Institute of Standards and Technology (NIST) is planned to continue in FY 2016.
- Nanotechnology Knowledge Infrastructure ($19.0 million) – Activities surrounding the fundamental, interconnected elements of collaborative modeling, a cyber-toolbox, and data infrastructure for nanotechnology, leveraging and extending existing and emerging resources, programs, and technologies to create an infrastructure to accelerate the vetting of new knowledge and to enable effective data utilization. This initiative aims to provide a community-based, solution-oriented knowledge infrastructure for discovery, innovation and nanoinformatics (with NNI agencies). The Network for Computational Nanotechnology (NCN) conducts key activities in support to this NSI.
- Nanotechnology for Sensors and Sensors for Nanotechnology ($7.50 million) – Use of nanotechnology and nanoscale materials to build more sensitive, specific, and adaptable sensors and development of new sensors to detect engineered nanomaterials across their life cycles in order to assess their potential impacts. This initiative supports materials and technologies that enable new sensing of biological, chemical, and nanoscale materials, including sensors for nano-EHS. A dedicated program on Nanobiosensors in the Chemical, Bioengineering, Environmental and Transport Systems (CBET) division in the Directorate for Engineering will support this effort.

Foundational Research

The FY 2016 Request includes $187.00 million for the discovery and development of fundamental knowledge pertaining to new phenomena in the physical, biological, and engineering sciences that occur at the nanoscale. The request also includes funding for research aiming to understand scientific and engineering principles related to nanoscale structures, processes, and mechanisms. Research is also supported that is aimed at discovery and synthesis of novel nanoscale and nanostructured materials. Research directed at identifying and quantifying the broad implications of nanotechnology for society, including social, economic, ethical, and legal implications is also supported. About 60 percent of the Materials Research Science and Engineering Centers (MRSECs) pursue NSE-related fundamental research.

Nanotechnology-Enabled Applications, Devices, and Systems

The FY 2016 Request includes $44.21 million for research and development that applies the principles of nanoscale science and engineering to create novel devices and systems, or to improve existing ones. This includes the incorporation of nanoscale or nanostructured materials and the processes required to achieve improved performance or new functionality, including metrology, scale up, manufacturing technology, and nanoscale reference materials and standards.

Research Infrastructure and Instrumentation

The FY 2016 Request includes $44.60 million for the establishment and operation of user facilities and networks, acquisition of major instrumentation, workforce development, and other activities that develop, support, or enhance the Nation's physical or human infrastructure for nanoscale science, engineering, and technology. This PCA includes research pertaining to the tools needed to advance nanotechnology research and commercialization, including next-generation instrumentation for characterization, measurement, synthesis, and design of materials, structures, devices, and systems. While student support to perform research is captured in other categories, dedicated educational and workforce efforts, ranging

from curriculum development to advanced training, are included here as resources supporting the human infrastructure of the NNI. NSF has under competition in FY 2015 the National Nanotechnology Coordinated Infrastructure (NNCI), with an annual budget estimated at $16 million that will be in operation in FY 2016, replacing the National Nanotechnology Infrastructure Network (NNIN). Additional Nanosystems Engineering Research Centers (NERCs) are under competition in FY 2015 and will be in operation in FY 2016.

Environment, Health, and Safety

In FY 2016, NSF will continue its funding for the Environmental, Health, and Safety (EHS) PCA at $22.48 million, representing nearly 5.4 percent of its overall NNI budget. Requests for research are primarily directed at understanding nano-bio phenomena and processes, as well as environmental, health, and safety implications and methods for reducing the respective risks of nanotechnology development.

Coordination with Other Agencies

The NSF NNI program is coordinated with 20 departments and agencies through the NSTCs subcommittee on Nanoscale Science, Engineering and Technology (NSET). Some specific coordination efforts are:

- Sustainable Nanomanufacturing (National Institute of Standards and Technology (NIST), Department of Energy (DOE), Environmental Protection Agency (EPA), National Institutes of Health (NIH), National Institute for Occupational Safety and Health (NIOSH), Occupational Safety and Health Administration (OSHA), U.S. Department of Agriculture/Food Safety (USDA/FS));
- NSF and Department of Defense (DOD)/Air Force Office of Scientific Research (AFOSR) collaborate on the Two-Dimensional Atomic-layer Research and Engineering (2-DARE) program that has a competition in 2015 for four-year group awards;
- Nanoelectronics (NIST, DOD, DOE, Intelligence Community (IC)/Director of National Intelligence (DNI), National Aeronautics and Space Administration (NASA));
- Environmental issues (EPA, USDA/National Institute of Food and Agriculture (NIFA), Consumer Product Safety Commission (CPSC));
- Solar energy conversion (DOE, IC/DNI, NASA, NIST, USDA/NIFA);
- NSECs, NNIN, and NCN centers and networks (DOD, NASA, DOE, NIH); and
- Nanosensors (NIH, and USDA).

These agencies also partner with NSF to sponsor joint workshops on nanotechnology research directions, and representatives from agencies involved in NNI activities participate in grantees conferences.

NNI Funding by Program Component Area

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
1. Nanotechnology Signature Initiatives	$122.49	$114.57	$118.07
Nanotechnology for Solar Energy	*29.50*	*27.67*	*27.67*
Sustainable Nanomanufacturing	*30.66*	*23.40*	*26.40*
Nanoelectronics for 2020 and Beyond	*34.44*	*37.00*	*37.50*
Nanotechnology Knowledge Infrastructure	*11.33*	*19.00*	*19.00*
Nanotechnology for Sensors	*16.56*	*7.50*	*7.50*
2. Foundational Research	212.22	186.80	187.00
3. Nanotechnology-Enabled Applications, Devices, and Systems	54.85	45.00	44.21
4. Research Infrastructure and Instrumentation	53.53	44.54	44.60
5. Environment, Health, and Safety	21.45	22.47	22.48
Total, NNI	**$464.54**	**$413.38**	**$416.36**

Totals may not add due to rounding.

NETWORKING AND INFORMATION TECHNOLOGY RESEARCH AND DEVELOPMENT (NITRD)

Total Funding for NITRD

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
Biological Sciences	$99.00	$99.00	$99.00
Computer and Information Science and Engineering	892.60	921.73	954.41
Education and Human Resources	9.50	9.50	9.50
Engineering	19.80	18.75	18.75
Geosciences	24.00	24.00	23.00
Mathematical and Physical Sciences	78.72	81.80	81.10
Social, Behavioral, and Economic Sciences	28.23	31.20	31.20
Total, NITRD	**$1,151.85**	**$1,185.98**	**$1,216.96**

Totals may not add due to rounding.

The National Science Foundation is a primary supporter of the Networking and Information Technology Research and Development (NITRD) program. NSF's NITRD portfolio includes all research, infrastructure, and education investments in the Computer and Information Science and Engineering (CISE) directorate, as well as contributions from all other directorates across the agency, enabling investments in every NITRD Program Component Area (PCA). NSF's Assistant Director for CISE is co-chair of the NITRD Subcommittee of the National Science and Technology Council's Committee on Technology. In addition, NSF works in close collaboration with other NITRD agencies and participates at the co-chair level in five of the seven PCA Coordinating Groups and three of the Senior Steering Groups.

NSF's FY 2016 Request continues strong support for NITRD at a level of $1.22 billion; this represents an increase of 2.6 percent above the FY 2015 Estimate. NITRD activities represent approximately 16 percent of NSF's FY 2016 budget. CISE's support comprises approximately 78 percent of NSF's NITRD activities.

Several NSF-wide investments, both new and continuing, are reflected in various NITRD PCAs:

- Advanced Manufacturing investments encompass research in nanotechnology, cyber-physical systems, and robotics, as well as expanded industry/university cooperation. Activities are supported in High End Computing Research and Development; High End Computing Infrastructure and Applications; and High Confidence Software and Systems.
- The Comprehensive National Cybersecurity Initiative (CNCI) supports activities in Cybersecurity and Information Assurance.
- Cyber-Enabled Materials, Manufacturing, and Smart Systems (CEMMSS), a collaboration among BIO, CISE, ENG, and MPS, expands advanced manufacturing technologies research in the Cyber-Physical Systems (CPS) program, the National Robotics Initiative (NRI), and the Materials Genome Initiative to accelerate advances in 21st century smart engineered systems. CEMMSS will establish a scientific basis for engineered systems interdependent with the physical world and social systems, synthesize multi-disciplinary knowledge to model and simulate systems in their full complexity and dynamics, and develop a smart systems technology framework. CEMMSS supports activities in High End Computing Research and Development; High Confidence Software and Systems; Human-Computer Interaction and Information Management; Software Design and Productivity; and Social, Economic, and Workforce Implications of IT and IT Workforce Development.

- Cyberinfrastructure Framework for 21st Century Science, Engineering, and Education (CIF21), a collaboration among all NSF directorates, is designed to develop and deploy comprehensive, integrated, sustainable, and secure cyberinfrastructure to accelerate research and new functional capabilities in computational and data-intensive science and engineering, primarily supporting investments in six program component areas: High End Computing Research and Development; High End Computing Infrastructure and Applications; Large Scale Networking; Human-Computer Interaction and Information Management; Software Design and Productivity; and Social, Economic, and Workforce Implications of IT and IT Workforce Development.
- Enhancing Access to the Radio Spectrum (EARS) is a collaboration among CISE, ENG, and MPS to identify bold new concepts with the potential to improve the efficiency of radio spectrum utilization, and in the ability for traditionally underserved Americans to benefit from current and future wireless-enabled goods and services. Investment in EARS supports High End Computing Research and Development, High End Computing Infrastructure and Applications, and Large Scale Networking.
- The new Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS) investment, a collaboration among all NSF directorates, supports Cybersecurity and Information Assurance, High Confidence Software and Systems, Large Scale Networking, and Software Design and Productivity. It also includes support for High End Computing Infrastructure and Applications through investments in advanced computational infrastructure that will provide additional resources in support of multidisciplinary research in INFEWS.
- Investments in NSF INCLUDES (Inclusion across the Nation of Communities of Learners that have been Underrepresented for Diversity in Engineering and Science), a collaboration among all NSF directorates, support the Social, Economic, and Workforce Implications of IT and IT Workforce Development activity.
- The National Robotics Initiative (NRI), a cross-agency initiative engaging four U.S. agencies (NSF, National Aeronautics and Space Administration, National Institutes of Health, and the U.S. Department of Agriculture) and four directorates at NSF (CISE, ENG, EHR and SBE) provides U.S. leadership in robotics science and engineering research and education aimed at the development of co-robots, which work cooperatively with humans in application domains, such as advanced manufacturing, emergency response, and assistive healthcare. Activities are supported in Human-Computer Interaction and Information Management; High Confidence Software and Systems; Software Design and Productivity; and Social, Economic, and Workforce Implications of IT and IT Workforce Development.
- The new Risk and Resilience NSF-wide investment area, a collaboration among CISE, ENG, GEO and SBE, supports High End Computing; Research and Development; Large Scale Networking; and Social, Economic, and Workforce Implications of IT and IT Workforce Development.
- Secure and Trustworthy Cyberspace (SaTC), a collaboration among CISE, EHR, ENG, MPS and SBE, aligns NSF's cybersecurity investments with the national cybersecurity strategy, *Trustworthy Cyberspace: Strategic Plan for the Federal Cybersecurity Research and Development Program*.[1] SaTC supports scientific foundations, induces change, maximizes research impact, and accelerates transitions to practice. SaTC supports activities in Cybersecurity and Information Assurance.
- The Understanding the Brain (UtB) investment, a collaboration among BIO, CISE, EHR, ENG, MPS and SBE, supports activities in High End Computing Infrastructure and Applications End Computing Infrastructure and Applications; High Confidence Software and Systems; Human Computer Interaction and Information Management; Software Design and Productivity; and Social, Economic, and Workforce Implications of IT and IT Workforce development. These activities also support part

[1] www.whitehouse.gov/sites/default/files/microsites/ostp/fed_cybersecurity_rd_strategic_plan_2011.pdf

of NSF's contributions to the Administration's Brain Research through Advancing Innovative Neurotechnologies (BRAIN) Initiative. It also includes support for High End Computing Infrastructure and Applications through investments in advanced computational infrastructure that will provide additional resources in support of multidisciplinary research in UtB.

- NSF investments in urban science, a collaboration among CISE, ENG and SBE, support the High Confidence Software and Systems activity.

FY 2016 NSF Investments by Program Component Area (PCA)

The following information focuses on FY 2016 NSF investments, both new and continuing, by PCA.

Large Scale Networking (LSN) ($130.84 million) CISE, ENG, and MPS will support research in new wireless communications, spectrum sharing architectures and services, and mobile computing, as well as development of wireless testbeds as part of EARS. A portion of NSF's investment in CIF21 will address broadband applications and research on end-to-end performance from the desktop to major scientific and computational facilities. Through INFEWS, CISE will invest in research related to control, automation, and optimization of the complex systems underlying the nexus of food, energy and water. Moreover, CISE will support advances in large-scale resilient, secure, and interoperable research cyberinfrastructure through the Risk and Resilience investment area. CISE will also provide additional support for networking and computing infrastructure.

Cybersecurity and Information Assurance (CSIA) ($111.73 million) CSIA includes support for CNCI and NSF's SaTC program. Increased CISE investments in SaTC, in partnership with EHR, ENG, MPS, and SBE, aim to support scientific foundations, induce change, maximize research impact, and accelerate transition to practice. This area also includes support from CISE for the NSF-wide INFEWS investment, with a focus on ensuring the safety and security of food, energy, and water resources, and the systems that facilitate their generation, distribution, and consumption through comprehensive, integrated research and modeling of these sociotechnical systems.

High End Computing Research and Development (HEC R&D) ($138.37 million) HEC R&D support includes continued increased investment in Risk and Resilience, which focuses on advances in large-scale resilient, secure and interoperable research cyberinfrastructure and systems. Additionally, support is provided for CISE's nanotechnology research, including participation in the National Nanotechnology Initiative. HEC R&D also includes increased support for research in Clean Energy Technologies by CISE, focusing on research that will develop the theory and design principles to effectively tackle energy versus computation and communication tradeoffs; and the development of new theory, algorithms, and design principles to optimize energy-computational performance in computing and communications systems. HEC R&D also includes support for CIF21 to develop new functional capabilities in support of highly parallel computing and big data analytics, as well as research on technical and economic models for flexible spectrum access, real-time auctions, and on-demand spectrum services as part of EARS. MPS will support research on quantum effects and their use for information science, potentially leading to new paradigms for high end computing.

High End Computing Infrastructure and Applications (HEC I&A) ($221.40 million) HEC I&A includes increased efforts by the Advanced Cyberinfrastructure (ACI) division in CISE to develop software and algorithms for high end computing systems as well as Advanced Computational Infrastructure. Through increased data and computational capacity, CISE will support multidisciplinary research in NSF priority areas including INFEWS and UtB. HEC I&A also includes MPS, ENG, and CISE investments in new computational methods, algorithms, robust software, and other computational tools to support researchers in the mathematical and physical sciences, and engineering through support for programs such as Computational Data-Enabled Science and Engineering. The CISE investment in computational

infrastructure as part of CIF21 is reflected here, as well as the development of wireless testbeds that support experimentation with new wireless technology services as part of EARS. GEO supports EarthCube, a CIF21 investment that sustains cyberinfrastructure for the geosciences. HEC I&A also includes investments in innovative partnerships and collaborations between universities and industries, including the Industry/University Cooperative Research Centers program (I/UCRC); GEO's support for operations and maintenance for the NCAR Wyoming Supercomputer facility; and BIO's support for development of pioneering informatics tools and resources including the iPlant Collaborative that have the potential to transform research in biology.

High Confidence Software and Systems (HCSS) ($97.94 million) CISE and ENG will increase investments in NRI and in CPS as part of CEMMSS, as well as continue investments in Smart and Connected Health (SCH). As development of the next generation of robotics proceeds, complete confidence in the systems supporting those that work beside, or cooperatively with, people in application domains, such as advanced manufacturing, emergency response, and healthcare, become increasingly important. High confidence surgical robots and medical devices are central to high-quality healthcare and building trust in robotic aids. CISE and ENG will support advanced manufacturing technologies research in cyber-physical systems, such as smart infrastructure that will blend traditional concrete-and-steel physical infrastructure systems with cyber-infrastructure systems such as computers, networks, and sensors. CISE's support for HCSS also includes investments in INFEWS and UtB. INFEWS investments focus on innovative optimization techniques, algorithms, and software development. UtB investments (which include support of the BRAIN Initiative) seek to foster new computational models across multiple scales, from molecules to behavior, toward accomplishing the ultimate goal of establishing an integrative, quantitative, and predictive theory of brain function in action and in context. Additionally, CISE, in collaboration with ENG and SBE, will support effective integration of networked computing systems, physical devices, data sources, and infrastructure leading to smart cities as part of a new multi-directorate activity in urban science. BIO's support for HCSS will expand and enhance access to the national resource of digital biological and paleontological data, and the Bio/computation Evolution in Action CONsortium (BEACON) Center established to study the power of evolutionary processes and to transfer those discoveries from biology into computer science and engineering design.

Human Computer Interaction and Information Management (HCI&IM) ($296.99 million) HCI&IM includes CISE support for NRI, a component of CEMMSS, SCH, and UtB. As part of the next generation of robotics, co-robot systems will be characterized by their flexibility and resourcefulness. They will use a variety of modeling or reasoning approaches, and use real-world data in real-time, demonstrating a level of intelligence and adaptability seen in humans and animals. SCH support will focus on human-centered intelligent information systems and tools that collect, mine, synthesize, protect, and share appropriate data and knowledge with healthcare organizations, practitioners, caregivers, and individuals to enable effective, safe, and well-informed decision-making by all stakeholders. UtB investments will enable the research needed to integrate computational models across scales; the development of innovative neurotechnologies to monitor brain function; and the expansion of the capacity of neuroscience infrastructure to integrate data across levels of analysis from molecular to behavioral scales.

HCI&IM also includes NSF investments in CIF21 related to BIGDATA analytics and visualization tools, and the development of mid-scale pilots and prototypes toward a comprehensive, scalable data infrastructure. BIO investments in HCI&IM will facilitate discovery through tools that integrate the published literature with the expanding universe of digital data collections, expand capacity for understanding through virtual environments, and make it practical for scientists to search vast collections of biological images simply and quickly. MPS investments will focus on the provision of new automated data-analysis pipelines that will provide initial reference images for the data-rich radio interferometers that are just coming on line, with analysis tools and guidance for those scientists who need to interact with the data in order to achieve image fidelities beyond those that can be delivered using automated

processing techniques. SBE will continue investments to increase the benefit of computer technologies to scientists, as well as non-science users, to develop user-friendly large-scale next-generation data resources and relevant analytic techniques to advance fundamental research in SBE areas of study, to support research on privacy in today's networked world, and to focus on research that advances the core scientific and technological means of managing, analyzing, visualizing, and extracting information from large data sets.

Software Design and Productivity (SDP) ($90.63 million) SDP support reflects increased investment in CIF21 with a focus on software sustainability, and new research on smart systems as part of CEMMSS. ENG's support for this PCA is primarily associated with the CPS and NRI components of the CEMMSS investment. CISE will make investments in the Software Institutes for Sustained Innovation (SI^2) program to catalyze new thinking, paradigms, and practices in developing and using software that is robust, reliable, usable, and sustainable under the CIF21 umbrella. CISE will also provide increased support for software as part of increased computational capacity supported by NSF. BIO support for SDP includes support for the interagency and international Collaborative Research in Computational Neuroscience program. BIO funds research involving the development of software and other computational tools to advance biological knowledge and computational innovations. SDP also includes support for SBE's National Center for Science and Engineering Statistics (NCSES) to continue exploration of new methods to enhance data collections, analysis, and sharing capabilities, which will help NCSES better serve its role of providing information on the science and engineering enterprise. In addition, SBE will continue to partner with CISE in exploring the emerging interface between computer science and the social, behavioral, and economic sciences.

Social, Economic, and Workforce (SEW) Implications of IT and IT Workforce Development ($129.06 million) As part of NRI, SEW research in CISE will focus on human-centered research in developing service robots, requiring significant advances in human-robot interaction. In addition, CISE's continued emphasis on SCH focuses on, for example, improvements in safe, effective, efficient, and patient-centered proactive and predictive health and wellness technologies. This also reflects CISE support for BIGDATA and e-science collaboration tools as part of CIF21, and support for cyberlearning and on-line education programs. CISE, ENG, and EHR will also continue to support the Cyberlearning and Future Learning Technologies program, which aims to integrate advances in technology with advances in understanding how people learn, with a focus on online learning environments. Research in cyberlearning will integrate advances in technology with learning, designing new technologies for integration in learning environments, and evaluating their use. EHR will continue to study the impact of information and communication technology on educational practice, new approaches to using technology in education, application and adaptation of technologies to promote learning in a variety of fields and settings, the effects of technology of learning, and efforts that advance teaching and learning opportunities utilizing cyberinfrastructure as part of its support. CISE will collaborate with EHR to support cyber-secure workforce development to enable a growing pipeline of researchers and educators, and to develop a citizenry that understands the security and privacy of the digital systems on which society depends. These efforts also will support science, technology, engineering, and mathematics education for the cyber-workforce through workforce programs and research and development in learning sciences. Such efforts will look to produce rapid progress on changing the balance of diversity and increase diversity in the cyber-workforce as part of the CISE support for the new NSF INCLUDES investment area. BIO support for SEW (for example through SESync, the National Socio-Environmental Synthesis Center) focuses on advancing the Nation's ability to incorporate and apply biological knowledge to economic development and other issues of societal importance. SBE will continue to support SEW by focusing on the nature and dynamics of IT impacts on technical and social systems.

NITRD Funding by Program Component Area

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
Large Scale Networking	$131.67	$127.91	$130.84
Cybersecurity and Information Assurance	103.42	106.80	111.73
High End Computing R&D	115.96	131.82	138.37
High End Computing Infrastructure and Applications	233.58	217.85	221.40
High Confidence Software and Systems	87.15	94.92	97.94
Human-Computer Interaction and Info Management	282.63	292.34	296.99
Software Design and Productivity	77.63	88.59	90.63
Social, Economic, and Workforce	119.80	125.75	129.06
Total, NITRD	**$1,151.85**	**$1,185.98**	**$1,216.96**

Totals may not add due to rounding.

U.S. GLOBAL CHANGE RESEARCH PROGRAM (USGCRP)

Total Funding for USGCRP

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
Biological Sciences	$91.00	$104.00	$110.04
Geosciences	195.15	202.09	209.09
Mathematical and Physical Sciences	14.37	6.50	3.50
Social, Behavioral and Economic Sciences	19.73	17.98	17.98
Total	**$320.25**	**$330.57**	**$340.61**

Totals may not add due to rounding.

Global change encompasses a wide range of planetary- and regional-scale changes in the Earth's natural and human systems. These changes involve atmospheric and ocean circulation and composition, the water cycle, biogeochemical cycles, land and sea ice, biological diversity, marine and terrestrial ecosystem health, resource and land use, urbanization, economic development, and more. The U.S. Global Change Research Program (USGCRP) provides the Nation and the world with the scientific knowledge necessary for understanding and predicting climate change and environmental responses, managing risk, and anticipating opportunities that may result from changes in climate and climate variability. Research conducted through the USGCRP (www.globalchange.gov) builds on the scientific advances of recent decades and deepens our understanding of how the interplay between human and natural systems affects the climate system and how the changing climate impacts those systems. The USGCRP involves thirteen U.S. agencies in a concerted interagency program of basic research, comprehensive observations, integrative modeling, and new approaches for translating scientific information for use by decision-makers. NSF provides support for a broad range of fundamental research activities that provide the scientific basis for climate-related policy and decisions.

The Earth's climate is determined by highly complex interactions between and among the atmosphere, hydrosphere, cryosphere, geosphere, and biosphere – all significantly influenced by human activities. NSF programs address these components by investing in fundamental discovery that utilizes the full range of intellectual resources of the scientific community, and research infrastructure that provides state-of-the-art capabilities. NSF strongly encourages interdisciplinary approaches, and focuses on fundamental Earth system processes and the consequences of change. High priorities for the agency include: data acquisition and information management activities necessary to support, and disseminate the results of, global change research; the enhancement of models designed to improve our understanding of Earth system processes and of feedbacks between ecosystems and the physical climate; the development of new, innovative Earth observing instruments and networks; the development of advanced analytic research methods; and preparation of a scientific workforce equipped to deal with the complexities of global change. NSF also supports fundamental research on the processes used by organizations to identify and evaluate policies for mitigation, adaptation, and other responses to varying environmental conditions. NSF-supported research on the science of impacts, vulnerability, and resilience as well as the enhancement and development of a range of climate and process models will continue to make an important contribution to climate assessment activities.

FY 2016 Areas of Emphasis

NSF's FY 2016 investment in USGCRP increases by $10.04 million, or 3.0 percent, above the FY 2015 Estimate. Because advancing scientific understanding requires a multi-faceted approach, NSF's emphasis areas span multiple USGCRP program component areas. In FY 2016, NSF will engage with other

USGCRP agencies on priorities for intra-seasonal to centennial predictability, predictions, and projections; water cycle research; understanding the impacts of global change on the Arctic region and effects on global climate; and fundamental research on actionable science. The major USGCRP foci for NSF include:

Improving our knowledge of Earth's past and present climate variability and change – NSF participates in the Multidisciplinary Earth and Human Understanding, Integrated Modeling, and Integrated Observations program component areas (PCAs) through activities to document and understand long-term climate cycles across the globe, as well as to better understand the natural variability of climate and the processes responsible for climate changes using a range of paleoclimate and instrumental data and modeling approaches. NSF also supports activities to improve our understanding of the frequency and intensity of extreme climate events, particularly wet and dry extremes of the water cycle, their causes, and how those may be manifested in the future. Upgrading and expanding critical environmental observing systems are vital to these efforts.

Improving our understanding of natural and human forces of climate change – NSF supports the Multidisciplinary Earth and Human Understanding PCA through activities spanning a broad range of disciplines and topics that seek to better understand the physical, geological, chemical, biological, and human components of the Earth system and their interactions. Examples of major foci include fundamental research on all aspects of the carbon cycle, the water cycle, atmospheric composition and greenhouse gas processes, marine and terrestrial ecosystems, and ocean and atmospheric circulations that both drive and respond to climate and global change. Human drivers of change include urbanization, population growth, and economic and technological development over a range of temporal scales. NSF has a strong commitment to fostering new interdisciplinary research approaches that allow exploration of the interdependencies across these areas.

Improving our capability to model and predict future conditions and impacts – NSF contributes to the Multidisciplinary Earth and Human Understanding and Integrated Modeling PCAs through research to examine major feedback processes between the climate and natural and human systems and will incorporate these into the next generation Community Earth System Model (CESM). High priority will be given to developing more complete representations of coupled interactive atmospheric chemistry, terrestrial and marine ecosystems, biogeochemical cycling, and middle atmospheric processes. NSF will continue to devote significant resources to advancing climate modeling capabilities from global and centennial to regional and decadal scales. In addition, NSF is encouraging the development of ecosystem and water models at regional scales, as well as models that integrate human system components such as risk, vulnerability, and decision-making.

Assessing the Nation's vulnerability to current and anticipated impacts of climate change – A key focus of the USGCRP is developing better means of assessing the impacts of climate change and the vulnerability and resilience of both human and natural systems to those changes, particularly in highly sensitive regions such as the Arctic. NSF participates in the Multidisciplinary Earth and Human Understanding, Integrated Modeling, Integrated Observations, and the Science of Adaptation and Science to Inform Adaptation Decisions PCAs through support of the basic research that underpins ongoing global change assessment and analysis efforts, particularly in developing the range of models needed for these assessments. NSF will support fundamental research regarding the science of adaptation, defined as the adjustment in natural or human systems to a new or changing environment that exploits beneficial opportunities or moderates negative effects. This research ranges from developing the theoretical framework for evaluating adaptation options (and avoiding unintended consequences of adaptation choices) to risk assessment and decision making. NSF will continue interdisciplinary research (including human factors) in water sustainability, biodiversity, ocean acidification, and vulnerable areas, particularly in the rapidly changing Arctic.

Providing climate information and decision support tools – NSF participates in the Science of Adaptation and Science to Inform Adaptation Decisions PCA through basic research on how humans impact climate and other natural systems, how people respond to changing natural conditions, and how human and natural systems engage in complex interactions across multiple spatial, temporal, and organizational scales. Support will continue for basic research on decision making under uncertainty associated with climate change, as well as for developing and testing decision-support tools that can be used by stakeholders to improve their decision making processes.

USGCRP Funding by Program Component Area (PCA)

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
Integrated Observations	$77.50	$88.00	$96.04
Multidisciplinary Earth and Human System Understanding	183.35	191.54	195.54
Integrated Modeling	44.65	35.28	33.28
Science of Adaptation and Science to Inform Adaptation Decisions	14.75	15.75	15.75
Total	**$320.25**	**$330.57**	**$340.61**

Totals may not add due to rounding.

PERFORMANCE

NSF PERFORMANCE FRAMEWORK

Introduction

Per the GPRA Modernization Act of 2010, this chapter, together with the Overview, contains basic information about NSF's mission, strategic plan, and priority goals, as well as NSF's Annual Performance Plan for FY 2016 and Annual Performance Report and Strategic Objective Progress Updates for FY 2014. Information about NSF's performance can also be found on performance.gov, which is updated quarterly with information about Agency and Cross-Agency Priority Goal achievement, and on the NSF site in the Performance and Financial Highlights Report.[1]

This Request highlights NSF's priorities for crosscutting investments and organizational efficiencies. NSF's Performance Plan for FY 2016 underscores the agency's overall priorities. In FY 2016, NSF continues its strategic monitoring of key program, infrastructure, and management investments. Together with NSF's longstanding performance goal to make timely award decisions, these performance goals provide the foundation of NSF's Performance Plan. The FY 2016 Plan also includes goals that focus on responsible stewardship of facility construction, virtual merit review panels, data-driven management reviews, and diversity and inclusion.

Strategic Plan and Strategic Objectives

Investing in Science, Engineering, and Education for the Nation's Future: NSF Strategic Plan for 2014 – 2018 lays out two strategic goals that embody the dual nature of NSF's mission to advance the progress of science while benefitting the Nation: *Transform the Frontiers of Science and Engineering* and *Stimulate Innovation and Address Societal Needs through Research and Education*.[1] A third goal, *Excel as a Federal Science Agency*, directs NSF to hold itself accountable for achieving excellence in carrying out its mission. This goal structure enables NSF to link its investments to longer-term outcomes. To bridge the gap between these strategic goals and measurable outputs, the Strategic Plan establishes a set of strategic objectives for each strategic goal (see next page).

Cross-Agency Priority Goals

NSF contributes to Cross-Agency Priority (CAP) Goals which relate closely to its mission, such as the CAP goal supporting Science, Technology, Engineering, and Mathematics (STEM) Education. Per the GPRA Modernization Act requirement to address CAP Goals in the agency Strategic Plan, the Annual Performance Plan, and the Annual Performance Report, please refer to www.performance.gov for more on the agency's contributions to those goals and progress, where applicable.

[1] www.nsf.gov/about/performance

2014-2018 NSF Strategic Framework

Strategic Goal	Strategic Objectives
G1: Transform the Frontiers of Science and Engineering	O1: Invest in fundamental research to ensure significant continuing advances across science, engineering, and education. O2: Integrate education and research to support development of a diverse STEM workforce with cutting-edge capabilities. O3: Provide world-class research infrastructure to enable major scientific advances.
G2: Stimulate Innovation and Address Societal Needs through Research and Education	O1: Strengthen the links between fundamental research and societal needs through investments and partnerships. O2: Build the capacity of the Nation to address societal challenges using a suite of formal, informal, and broadly available STEM educational mechanisms.
G3: Excel as a Federal Science Agency	O1: Build an increasingly diverse, engaged, and high-performing workforce by fostering excellence in recruitment, training, leadership, and management of human capital. O2: Use effective methods and innovative solutions to achieve excellence in accomplishing the agency's mission.

FY 2014 STRATEGIC OBJECTIVE PROGRESS UPDATES

In FY 2014, the National Science Foundation conducted seven Strategic Reviews in response to the requirement of the GPRA Modernization Act 2010 Section 1116(f). This section summarizes the actions that NSF plans to take in response to the Strategic Review recommendations.

Of the 26 recommended actions, 16 are planned to be implemented in the near-term (FY 2014 - FY 2015). An additional seven recommendations may be implemented in future years. The remaining three actions were determined to not be priorities for NSF, and there are no plans to take action on these recommendations.

Strategic Objective Progress Updates

Goal 1: Transform the Frontiers of Science and Engineering.
Objective 1: Invest in fundamental research to ensure significant continuing advances across NSF science, engineering, and education.

NSF has determined that performance towards this Objective is making noteworthy progress.

The Strategic Review for Goal 1/Objective 1 focused on the question of whether NSF has adequate mechanisms to fund interdisciplinary research (IDR) and potentially transformative research (PTR). Seven "Opportunities for Action or Improvement" were highlighted in the Summary of Findings. The working group for this strategic review noted that NSF currently has effective funding mechanisms in place, but existing mechanisms might not be employed uniformly across the Foundation. The first four recommended actions involve strengthening existing mechanisms to fund IDR and PTR by encouraging program directors to use existing mechanisms and providing them with the tools to co-review interdisciplinary proposals.

1. Reinforce NSF commitment to IDR in internal and external communications to ensure that IDR is viewed positively.
2. Increase transparency in incentives, such as through venture funds for jointly funded proposals, to increase the investments in interdisciplinary research through the core programs.
3. Recognize programs and program directors for supporting IDR and PTR.
4. Modify NSF e-business systems and processes to allow for IDR complexity. (Note: This was a performance goal in FY 2013 that was unmet.)

Because these recommendations affect all directorates at NSF, the Office of Integrative Activities (OIA) will provide leadership in prioritizing actions and developing plans for implementation through either the Integrated NSF Support Promoting Interdisciplinary Research and Education (INSPIRE) working group or other cross-foundation working groups. Implementation plans will be shared with the Senior Management Round Table in FY 2015.

The other three recommended actions involve the evaluation of IDR and PTR mechanisms:

5. Assess the impact of PTR funding across NSF through formal studies.
6. Assess PTR mechanisms, such as EArly Concept Grants for Exploratory Research (EAGERs) and Ideas Labs, which have been used for several years, but have not been assessed yet. A formative evaluation for INSPIRE has been initiated.
7. Institute an external retrospective study that compares the predicted transformative potential (from reviews and panel summaries) of awards and declines from 5-10 years ago with the actual outcomes.

In addition to the formative evaluation of INSPIRE, the Evaluation and Assessment Capability (EAC) in OIA will initiate feasibility studies for the evaluation of other mechanisms in FY 2016.

Strategic Goal 1: Transform the Frontiers of Science and Engineering.
Strategic Objective 2: Integrate education and research to support development of a diverse STEM workforce with cutting-edge capabilities.

Implicit in wording of this strategic objective is the assumption that there is a shared understanding of what "integrate education and research" means and, further, that integration increases diversity and quality in science and engineering. The Strategic Review for Goal 1/Objective 2 focused on examining these assumptions to understand the implications for achieving the objective. The following "Opportunity for Action or Improvement" was highlighted in the Summary of Findings:

> Convene a symposium on "Integration of Research and Education" to synthesize evidence relevant to the proposed theories of change, identify gaps in understanding, and develop a research agenda to determine ways to most effectively develop both a diverse and excellent workforce.

To address this recommendation, NSF will host an internal workshop in Q2 of FY 2015 to explore the multiple interpretations of the phrase "integration of education and research." The Division of Undergraduate Education in the Directorate for Education and Human Resources will take the lead in planning the workshop in collaboration with the Directorate for Geosciences. AAAS fellows will assist with workshop organization and efforts to fully engage all NSF directorates in this exploration.

Strategic Goal 1: Transform the Frontiers of Science and Engineering.
Strategic Objective 3: Provide world-class research infrastructure to enable major scientific advances.

The Strategic Review of Goal 1/Objective 3 examined whether NSF has adequate mechanisms to determine if our investments in large facilities enable major scientific advances. The review also investigated whether current resources are adequate to support NSF facilities. The following "Opportunity for Action or Improvement" was highlighted in the Summary of Findings:

> Evaluate the current and future resource and structural needs within the Foundation to successfully support its facilities. The increasing level of complexity of the facility programs that the NSF funds, as well as the recognition that the Foundation is changing the overall planning for the lifecycle of facilities, point to the time being ripe for the Foundation to address this issue.

The Large Facilities Office is facilitating the evaluation of the resource and structural needs within the Foundation to successfully support large, multi-user facilities through all life cycle stages. The first step will be a revision of the Large Facilities Manual (LFM) to update internal processes and procedures, clarify roles and responsibilities, and develop a standard terminology related to large facilities. Two important structural changes being implemented immediately are (1) formation of the Large Facilities Working Group (LFWG) for review of documentation and discussion of issues related to large facilities, and (2) transition to the Integrated Project Team (IPT) approach for better internal coordination of assurance and oversight responsibilities. All changes have been initiated in Q4 of FY 2014, and substantial progress is expected by mid-FY 2015.

Strategic Goal 2: Stimulate innovation and address societal needs through research and education.
Strategic Objective 1: Strengthen the links between fundamental research and societal needs through investments and partnerships.

NSF has determined that performance towards this Objective is making noteworthy progress.

The strategic review for Goal 2/Objective 1 focused on linking knowledge and practice. The review examined the current conventional wisdom for knowledge transfer, the various models and mechanisms available within NSF to link knowledge to practice, and identified gaps between what is needed and what NSF is currently doing to catalyze knowledge transfer. Three "Opportunities for Action or Improvement" were highlighted in the summary of findings:

1. Study new and emerging intellectual property (IP) practices, and disseminate the results in order to stimulate innovative thinking in IP management;
2. Study what outcome metrics would be realistic in collaborative research and licensing, and disseminate the results in order to help align the expectations between academe and industry; and
3. Convene a workshop to brainstorm how to further cultivate innovative thinking and entrepreneurship among students (building on NSF Innovation Corps (I-Corps™) successes), and what new models of education are emerging or will be appropriate. The ultimate goal is to cultivate industry-relevant skills and the mentality for technology commercialization among students.

The Directorate for Engineering will take the lead in addressing the first and third recommendations from this strategic review. In FY 2015, NSF will co-sponsor a national town hall meeting with the University-Industry Demonstration Partnership to disseminate IP best practices among universities to address the first recommendation. To address the third recommendation, NSF will convene the National Innovation Network (NIN) workshop in June of 2015. The workshop will include a review of the training, resource/tool development, and research efforts of the I-Corps™ Nodes and Sites to identify and develop promising ideas that can generate value and enhance the innovation capacity/ecosystem of the Nation. The second recommendation was determined to be beyond the scope of NSF's influence and will not be implemented.

Strategic Goal 2: Stimulate innovation and address societal needs through research and education.
Strategic Objective 2: Build the capacity of the Nation to address societal challenges using a suite of formal, informal, and broadly available STEM educational mechanisms.

The Strategic Review of Strategic Goal 2/Objective 2 examined whether NSF conveys its role in addressing societal challenges and promotes awareness of those challenges through STEM education mechanisms. It also investigated whether NSF has appropriate mechanisms to increase the capacity of STEM professionals to communicate, disseminate, and/or engage others in their research and education endeavors. The following "Opportunities for Action or Improvement" were highlighted in the Summary of Findings:

1. Develop and implement data collection on impact metrics with respect to NSF-developed communications.
2. Assess the quality of the proposal responses to the revised elements of the broader impacts criterion.
3. Conduct a cross-project, thematic evaluation of awards focused on professional development for STEM researchers to communicate, disseminate and/or engage others in their research and education endeavors.
4. Assess the impact of the "Becoming the Messenger" training and consider means to expand the program, if appropriate.
5. Consider strategies to facilitate coordinated broader impacts efforts above the project level.

Three of these recommendations were determined to be priorities in the near-term. The Office of Legislative and Public Affairs (OLPA) is in the process of identifying metrics and implementing a data collection to address the first recommendation. The EAC in OIA will lead the effort to assess the quality of the proposal responses to the revised elements of the broader impacts criterion and the actual consecution of those funded activities. The Directorate for Education and Human Resources (EHR) will address the last recommendation as part of the Improving Undergraduate STEM Education (IUSE) activity. As a first step, a portfolio analysis of the broader impacts/education and public outreach/diversity activities of a selected set of NSF-funded centers, major facilities, and infrastructure projects will be conducted to determine the range and types of activity focused on the level of undergraduate education. The third recommendation was determined to not be a priority in the near term because the number of awards that fund professional development to communicate research is too small to warrant the investment. The fourth recommendation was also deprioritized because there are no immediate plans to continue the "Becoming the Messenger" training or expand the program.

Strategic Goal 3: Excel as a Federal Science Agency.
Strategic Objective 1: Build an increasingly diverse, engaged, and high performing workforce by fostering excellence in recruitment, training, leadership, and management of human capital.

NSF has highlighted this Objective as a focus area for improvement.

The strategic review for Goal 3/Objective 1 addressed the following four questions:

- What are the recruitment, training, leadership, and management strategies to build the diverse, engaged, and high performing workforce needed to excel as a scientific agency?
- How do we realize the full benefits of synergy among diversity, inclusion, and engagement in nurturing a high performing workforce?
- How does NSF's workforce structure influence NSF's pursuit of a high performing organization that is diverse and engaged?
- What actions within agency control will have greatest positive impact on a diverse, engaged, and high performing workforce during and after the transition to Alexandria?

Five "Opportunities for Action or Improvement" were highlighted in the Summary of Findings:

1. Create the underlying logic models for how strategies related to recruitment, training, leadership, and human capital management influence building an increasingly diverse, engaged, and high performing workforce, with particular attention to interdependencies of strategies and outcomes.
2. Identify indicators of progress for a "diverse, engaged, and high performing" workforce and the data sources for establishing baselines and measuring progress.
3. Structure the developing human capital dashboard to make data and information on key indicators accessible to decision makers at a glance and enable deep dives for targeted action.
4. Use short "pulse" surveys, focus groups, and other mechanisms to understand what it will take to retain at least 70 percent of NSF's current permanent staff through the transition to Alexandria. Prioritize actions and strategies based on the result.
5. Create explicit strategies to replace both the rotator population and retirements anticipated between now and 2016.

The Division of Human Resources has focused near-term activities on actions two through five. The developing human capital dashboard mentioned in action 3 is being built around key issues of immediate importance (relevant to actions 4 and 5) as well as indicators of diversity, engagement, workforce

performance, recruitment/hiring, training and professional development, leadership, and broad initiatives in human capital management.

The implementation of a set of high-priority explicit strategies to retain at least 70 percent of NSF's current permanent staff through the transition to a new headquarters location, and to replace both the rotator population and retirements anticipated between now and then will address recommendations four and five. These strategies will be largely developed through the use of short "pulse" surveys, focus groups, and other mechanisms during FY 2016. Strategies to be developed will include a mix of workforce planning; recruitment and hiring, and retention strategies, such as action planning and implementation for employee engagement and diversity and inclusion; and improvements to performance management systems.

Strategic Goal 3: Excel as a Scientific Federal Agency.
Strategic Objective 2: Use effective methods and innovative solutions to achieve excellence in accomplishing the agency's mission.

The Strategic Review of Goal 3/Objective 2 examined the following four questions:

- What can organizational theory tell us about the strengths and weaknesses of NSF's structure and culture?
- What is the NSF management model and how does it affect our ability to use effective business methods and innovative solutions to achieve excellence in accomplishing the agency's mission?
- Is there evidence that our culture results in efficiency or inefficiency?
- What can we learn from similar organizations that achieve organizational excellence?

The following "Opportunities for Action or Improvement" were highlighted in the Summary of Findings:

1. Implement a cultural assessment, using evidence-based survey tools, with the goal of identifying our organizational strengths and opportunities for improvement. The results of the cultural assessment will be reviewed in the context of the results of the Federal Employee Viewpoint Survey to describe actionable objectives towards agency excellence.
2. Institutionalize an assessment process with the goal of identifying strategic issues and potential solutions. An effective, but minimally burdensome approach could be to identify actions through the cultural assessment and representative case studies and then use a Strengths Weaknesses Opportunities & Threats (SWOT) analysis with stakeholders from across the Foundation.
3. Assess NSF's approach to the use of working groups against the academic literature to determine if it is using a governance model with an unambiguous decision structure that fully leverages the strength and flexibility of these collaborative teams.
4. Identify other agencies who achieve their mission though the award of grants to determine: what, if any self-analysis they may have done; what strategic challenges they identified; if their strategic challenges are consistent with NSF's; and if NSF can leverage their experiences and opportunities for improvement.

The recommendation that was considered to be the highest priority and a necessary first step is the implementation of a formal cultural assessment to document NSF's organizational culture, identify the culture's impact on the agency's business methods, and provide insight into opportunities for improved business operations. The results of the assessment may also serve as a means to address issues described in the Federal Employee Viewpoint Survey. The following actions, some predicate to initiating the cultural assessment and others subsequent to its completion, will be undertaken so that the results can be fully leveraged:

- Develop an "ideal" agency cultural profile using input from NSF senior leadership and peer-to-peer benchmarking with one or more federal science agencies.
- Mine the results of the most recent Federal Employee Viewpoint Survey for a fuller agency perspective on agency current state and opportunities for improvement.
- Compare the results of the NSF cultural assessment against the ideal agency cultural profile; identify opportunities for greater alignment with the ideal; and, develop a corresponding action plan to achieve alignment.
- Institutionalize a recurring process to assess NSF progress toward alignment against the ideal benchmark.

The Office of Budget, Finance, and Award Management (BFA) in collaboration with the Directorate for Social, Behavioral and Economic Sciences (SBE) will lead the effort.

Implementation of the remaining recommendations will be considered in FY 2016 following the cultural assessment. The third recommendation, to assess the use of working groups, is considered to be a high priority action that could significantly improve efficiency of work flow at NSF.

Summary table of actions to be taken.

Strategic Goal/Obj.	Action	Status of Proposed Action	Lead Org.
G1/01	Reinforce NSF commitment to IDR in internal and external communications to ensure that IDR is viewed positively.	OIA will lead efforts to prioritize actions and determine what steps should be taken in the near term to implement those that are determined to be priorities.	OD/OIA
G1/01	Increase transparency in incentives, such as through venture funds for jointly funded proposals, to increase the investments in interdisciplinary research through the core programs.		
G1/01	Recognize programs and program directors for supporting IDR and PTR.		
G1/01	Modify NSF e-business systems and processes to allow for IDR complexity.	Planning is underway in the INSPIRE working group.	OD/OIA CPIC, DIS
G1/01	Assess the impact of PTR funding across NSF through formal studies.	The Evaluation and Assessment Capability (EAC) will initiate an external evaluation of the impact achieved by different funding mechanisms used to identify and fund interdisciplinary and potentially transformative research, including core programs.	OD/OIA
G1/01	Assess PTR mechanisms, such as EAGERs and Ideas Labs, which have been used for several years, but have not been assessed yet. A formative evaluation for INSPIRE has been initiated.		
G1/01	Institute an external retrospective study that compares the predicted transformative potential (from reviews and panel summaries) of awards and declines from 5-10 years ago with the actual outcomes.		
G1/02	Convene a symposium on "Integration of Research and Education" to synthesize evidence relevant to the proposed theories of change, identify gaps in understanding, and develop a research agenda to determine ways to most effectively develop both a diverse and excellent workforce.	NSF will host an internal workshop in Q2 of FY 2015 to explore the multiple interpretations of the phrase "integration of education and research."	EHR/DUE with GEO

Strategic Goal/Obj.	Action	Status of Proposed Action	Lead Org.
G1/03	Evaluate the current and future resource and structural needs within the Foundation to successfully support its facilities. The increasing level of complexity of the facility programs that the NSF funds, as well as the recognition that the Foundation is changing the overall planning for the lifecycle of facilities, point to the time being ripe for the Foundation to address this issue.	The Large Facilities Office (LFO) will play a key role in implementing this recommendation through a revision of the Large Facilities Manual, the formation of a "Large Facilities Working Group", and the transition to the "Integrated Project Team" approach for better internal coordination of assurance and oversight responsibilities.	BFA/LFO
G2/01	Study new and emerging IP practices, and disseminate the results in order to stimulate innovative thinking in IP management.	In FY 2015 NSF will co-sponsor a national town hall meeting with the University-Industry Demonstration Partnership to disseminate IP best practices among universities.	ENG
G2/01	Study what outcome metrics would be realistic in collaborative research and licensing, and disseminate the results in order to help align the expectations between academe and industry.	This recommendation has been determined to be beyond the scope of NSF's influence.	ENG
G2/01	Convene a workshop to brainstorm how to further cultivate innovative thinking and entrepreneurship among students (building on NSF I-Corps™ successes), and what new models of education are emerging or will be appropriate. The ultimate goal is to cultivate industry-relevant skills and the mentality for technology commercialization among students.	NSF will convene the National Innovation Network (NIN) workshop in June of 2015. The workshop will include a review of the training, resource/tool development, and research efforts of the I-Corps™ Nodes and Sites to identify and develop promising ideas that can generate value and enhance the innovation capacity and ecosystem of the Nation.	ENG
G2/02	Develop and implement data collection on impact metrics with respect to NSF-developed communications.	Efforts are underway to identify metrics and implement a data collection.	OLPA
G2/02	Assess the quality of the proposal responses to the revised elements of the broader impacts criterion.	OIA will conduct an assessment of the quality of the proposal responses to the revised elements of the broader impacts criterion and the actual consecution of those funded activities.	OD/OIA

Strategic Goal/Obj.	**Action**	**Status of Proposed Action**	**Lead Org.**
G2/02	Conduct a cross-project, thematic evaluation of awards focused on professional development for STEM researchers to communicate, disseminate, and/or engage others in their research and education endeavors.	This recommendation has been de-prioritized because the number of awards that fund professional development to communicate research is too small to warrant the investment in an evaluation.	N/A
G2/02	Assess the impact of the "Becoming the Messenger" training and consider means to expand the program, if appropriate.	This recommendation was deprioritized because OLPA will not be continuing "Becoming the Messenger" in the near-term.	OLPA
G2/02	Consider strategies to facilitate coordinated broader impacts efforts above the project level.	In FY 2015- FY 2016, as part of the IUSE activity, NSF will conduct a portfolio analysis of all of the broader impacts/education and public outreach/diversity ac-tivities of a selected set of NSF-funded centers, major facilities, and infrastructure projects to determine the range and types of activity focused at the level of undergraduates or undergraduate education.	EHR, IUSE working group
G3/01	Create the underlying logic models for how strategies related to recruitment, training, leadership, and human capital management influence building an increasingly diverse, engaged, and high performing workforce, with particular attention to inter-dependencies of strategies and outcomes.	These actions are expected to be taken in FY 2015 and FY 2016 following strategy development.	OIRM/HRM
G3/01	Identify indicators of progress for a "diverse, engaged, and high performing" workforce and the data sources for establishing baselines and measuring progress.		

Strategic Goal/Obj.	**Action**	**Status of Proposed Action**	**Lead Org.**
G3/01	Structure the developing human capital dashboard to make data and information on key indicators accessible to decision makers at a glance and enable deep dives for targeted action.	Actions associated with this recommendation are underway. A mock-up for the dashboard structure is complete as a static presentation. Current efforts are targeted at making the dashboard more interactive and adding additional information, such as Employee Viewpoint Survey data.	OIRM/HRM
G3/01	Use short "pulse" surveys, focus groups, and other mechanisms to understand what it will take to retain at least 70 percent of NSF's current permanent staff through the transition to Alexandria. Prioritize actions and strategies based on the result.	Outreach activities have begun to identify specific actions and strategies. Strategies to be developed will include a mix of workforce planning, recruitment, hiring and retention strategies (action planning for employee engagement, diversity and inclusion) and improvements to performance management systems.	OIRM/HRM
G3/01	Create explicit strategies to replace both the rotator population and retirements anticipated between now and 2016.		
G3/02	Implement a cultural assessment, using evidence-based survey tools, with the goal of identifying our organizational strengths and opportunities for improvement. The results of the cultural assessment will be reviewed in the context of the results of the Federal Employee Viewpoint Survey to describe actionable objectives towards agency excellence.	NSF will contract for services to support this undertaking.	SBE/BFA
G3/02	Institutionalize an assessment process with the goal of identifying strategic issues and potential solutions. An effective, but minimally burdensome approach could be to identify actions through the cultural assessment and representative case studies and then use a Strengths Weaknesses Opportunities & Threats (SWOT) analysis with stakeholders from across the Foundation.	Implementation in FY 2016 contingent on the results of the cultural assessment and the working group assessment.	BFA

Strategic Goal/Obj.	**Action**	**Status of Proposed Action**	**Lead Org.**
G3/02	Assess NSF's approach to the use of working groups against the academic literature to determine if it is using a governance model with an unambiguous decision structure that fully leverages the strength and flexibility of these collaborative teams.	Implementation in FY 2016 following the analysis of the cultural assessment.	SBE/BFA
G3/02	Identify other agencies who achieve their mission through the awarding of grants. The objectives would be to determine: what, if any self-analysis they may have done; what strategic challenges they identified; if their strategic challenges are consistent with NSF's; and if NSF can leverage their experiences and opportunities for improvement.	Implementation in FY 2016 contingent on the results of the cultural assessment and the working group assessment.	BFA

FY 2014 ANNUAL PERFORMANCE REPORT

Each fiscal year the National Science Foundation is required to prepare three reports to provide financial management and program performance information. This report, the Annual Performance Report (APR), includes the results of NSF's FY 2014 performance goals, including the agency's priority goals, related to the Government Performance and Results Act of 1993 (GPRA) and the GPRA Modernization Act of 2010. The other two reports are the Agency Financial Report (AFR), and the Performance and Financial Highlights Report. All three of these reports can be found on the Budget and Performance page of the NSF web site (www.nsf.gov/about/performance/).

In FY 2014, NSF published a new Strategic Plan, *Investing in Science, Engineering, and Education for the Nation's Future: NSF Strategic Plan for 2014 – 2018*, and performed its first Strategic Reviews of the objectives in that Plan. In FY 2014, NSF also tracked progress toward its three strategic goals, using ten performance goals and three priority goals. Out of the ten goals with targets in FY 2014, nine were fully or partially achieved and one was not achieved. Below is a tabular overview.

Goal ID	Strategic Alignment			Goal Short Name	FY 2014 Result
	G1	G2	G3		
1	O3	O1	O2	Priority Goal: Public Access	Progress made. No FY 2014 targets.
2	O3	O1		Priority Goal: Data Science	
3			O2	Priority Goal: Level Workload	
4	All	All		Key Program Investments[1,2]	Partially Achieved
5	O2	O2		Improve Undergraduate Education	Achieved
6	O2			Enhance National GRFs[1]	Achieved
7	O2			Career-Life Balance	Achieved
8	O3			Research Infrastructure Investments	Achieved
9			O1	Diversity and Inclusion	Not Achieved
10			All	Evidence-Based Reviews[1,2]	Achieved
11			O2	Financial System Modernization	Achieved
12			O2	Customer Service: Time To Decision	Achieved
13			O2	Virtual Merit Review Panels	Achieved

This section presents results for each performance goal in its strategic context, with reference to strategic goals, objectives, and targets from NSF's 2014-2018 Strategic Plan. Multiple years of trend data are available for NSF's longest-standing quantitative performance measures, time to decision (Goal 12) and the monitoring of construction projects (Goal 8). Other performance goals monitor progress towards multiyear goals, such as implementation of a new process or program (Goals 7 and 13) or an operational improvement (Goals 9 and 11). Goals 1 through 6 are new in 2014 and have less or no historical data associated with them.

A statement by the NSF Director verifying the reliability and completeness of the performance data in this report can be found in the FY 2014 Performance and Financial Highlights report at www.nsf.gov/about/history/annual-reports.jsp.

[1] Independent verification and validation (V&V) identified data limitations for this goal in FY 2014. For more information, see V&V section under "Other Information" in this chapter.
[2] Goal continues in FY 2015 and will be re-V&V'd.

Goal 1, Priority Goal: Ensure Public Access to Publications
Lead Organization: Office of the Director.

Strategic Alignment:

- G1/O3, Provide world-class research infrastructure to enable major scientific advances.
- G2/O1, Strengthen the links between fundamental research and societal needs through investments and partnerships.
- G3/O2, Use effective methods and innovative solutions to achieve excellence in accomplishing the agency's mission.

Fiscal Year	Goal Statement	Target Measure, Milestone, or Deliverable	Result
2014-2015 (new goal)	Ensure Public Access to Publications	By September 30th, 2015, NSF-funded investigators will be able to deposit versions of their peer-reviewed articles in a repository to make them available to the public within one year of publication.	Progress made towards achievement in FY 2015.

Discussion
Activities and achievements for this goal in FY 2014 fall into several categories. For more information, see the goal page on performance.gov, www.performance.gov/content/ensure-public-access-publications.

Development of manuscript submission system. NSF is ahead of schedule on this milestone to finalize an Interagency Agreement by the end of March 2015. In June 2014, NSF entered into a Memorandum of Agreement for external repository services and finalized an Interagency Agreement with the Department of Energy, Office of Scientific and Technical Information (DOE/OSTI) to support system development.

Changes to internal systems. NSF has made satisfactory progress in identifying proposed changes to internal systems to accommodate system integration. The detailed requirements gathering exercise, completed in FY 2014, together with the technical work, will enable NSF to remain on track for a system release in the fall of 2015. NSF completed testing for three critical elements of the internal/external system integration in FY 2014. Additional proof of concept testing, preliminary interface design, and a second round of usability requirements gathering and feedback are underway.

Outreach. NSF has made satisfactory progress in undertaking outreach and discussions with different stakeholder groups, other federal agencies, and possible public/private partners. With NSF support, the National Research Council stood up a Forum on Open Science in October 2014 and held two meetings in the summer of 2014, with two more anticipated in FY 2015. The posting of an approved public access plan to the NSF website is anticipated in early 2015.

Goal 2, Priority Goal: Increase Data Scientists and Data Infrastructure

Lead Organizations: Directorate for Computer and Information Sciences and Engineering, Directorate for Education and Human Resources.

Strategic Alignment:

- G1/O3, Provide world-class research infrastructure to enable major scientific advances.
- G2/O1, Strengthen the links between fundamental research and societal needs through investments and partnerships.

Fiscal Year	Goal Statement	Target Measure, Milestone, or Deliverable	Result
2014-2015 (new goal)	Increase Data Scientists and Data Infrastructure	By September 30th, 2015, implement mechanisms to support the training and workforce development of future data scientists; increase the number of multi-stakeholder partnerships to address the Nation's big-data challenges; and increase investments in current and future data infrastructure extending data –intensive science into more research communities.	Progress made towards achievement in FY 2015.

Discussion

Activities and achievements for this goal in FY 2014 fall into several categories. For more information, see the goal page on performance.gov, www.performance.gov/content/increase-nation%E2%80%99s-data-science-capacity.

Human Capital Development

- Funded and held a workshop on April 11-12, 2014 at the National Academy of Sciences on "Training Students to Extract Value from Big Data."
- Established a baseline for the number of undergraduate, certificate, and graduate programs in Big Data/data science/data analytics.
- Completed inventory of NSF programs that could appropriately include an emphasis on the preparation of data scientists, and included such emphasis in two reissued solicitations in FY 2014.
- Posted solicitation for the new National Science Foundation Research Traineeship (NRT) Program, with a priority theme to address fundamental challenges advancing computation- and data-enabled science and engineering.

Partnerships. NSF funded and held a workshop on November 12, 2013 with the White House Office of Science and Technology Policy on "Data to Knowledge to Action." Thirty multi-stakeholder partnerships with over 90 partners were announced. In September 2014, NSF released a Request For Information in the Federal Register (www.gpo.gov/fdsys/pkg/FR-2014-09-03/html/2014-20806.htm) to explore the establishment of a national network of Big Data Regional Innovation Hubs, which would scale up the kinds of activities and partnerships established at the Data to Knowledge to Action event.

Infrastructure. NSF issued solicitations and conducted competitions for the Data Infrastructure Building Blocks (DIBBS) and the Critical Techniques and Technologies for Advancing Big Data Science & Engineering (BIGDATA) programs. Funding decisions are anticipated in late FY 2015.

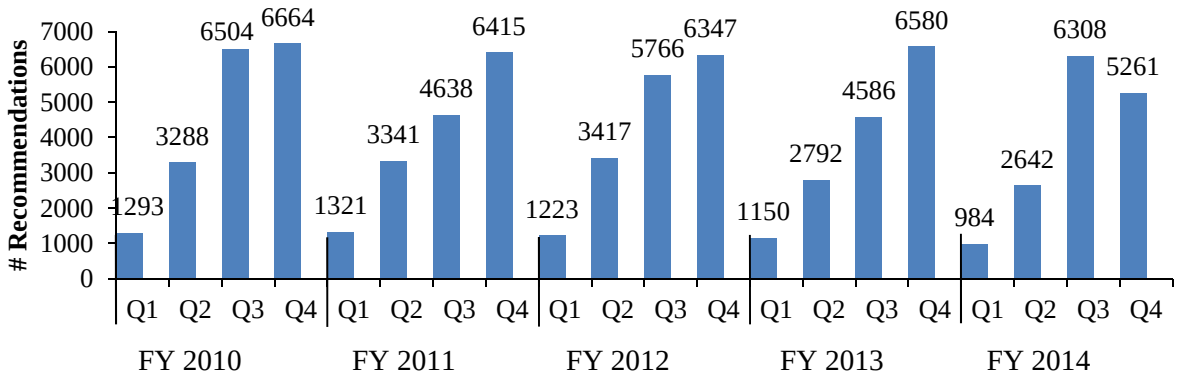
Goal 3, Priority Goal: Optimize the Award Process to Level Workload
Lead Organization: Office of Budget, Finance, and Award Management.

Strategic Alignment:

- G3/O2, Use effective methods and innovative solutions to achieve excellence in accomplishing the agency's mission.

Fiscal Year	Goal Statement	Target Measure, Milestone, or Deliverable	Result
2014-2015 (new goal)	Optimize the Award Process to Level Workload	By September 30, 2015, meet targets to level distribution of awards across the fiscal year and subsequently improve awardee capacity to effectively manage research funding.	Progress made towards achievement in FY 2015.

Actual Results for Preceding Fiscal Years



Discussion
For more information on this goal, see the goal page on performance.gov, www.performance.gov/content/optimize-award-process-level-workload.

FY 2014 activities towards this goal were focused on establishing implementation teams for each directorate and on piloting approaches that may provide novel and/or innovative solutions to leveling proposal and award workload across the fiscal year. While the targets for this goal are for FY 2015, the FY 2014 data (above, with trend information for context) show that NSF began to see a shift in its annual workload of awards recommended for funding into the third quarter in FY 2014. This was due to two major factors unique to FY 2014:

- The lapse in funding authority in Q1, which halted receipt and delayed review of proposals NSF-wide. The hiatus is believed to be the primary reason for the shift of the annual workload out of the first and second quarter.
- Preparations for transition to a new financial system in Q4, which went live in early FY 2015. The changes to close-out processes required by the financial system transition resulted in movement of more than five percent of recommended awards out of the fourth quarter.

Goal 4. Key Program Investments

Lead Organization: Performance Improvement Office, Office of Budget, Finance, and Award Management.

Strategic Alignment:

- Strategic Goal 1, Transform the Frontiers of Science and Engineering
- Strategic Goal 2, Stimulate Innovation and Address Societal Needs through Research and Education

Fiscal Year	Goal Statement	Target Measure, Milestone, or Deliverable	Result
2014 (new goal)	Meet critical targets for key FY 2014 program investments.	Monitor the progress of the following investments using a common set of milestones and indicators: • CEMMSS • CIF21 • I-Corps™ • INSPIRE • SaTC • SEES	Partially achieved. Four of six programs monitored.

Discussion

NSF instituted the Key Program Investments goal for FY 2014 to track the interim progress of major investments towards their long-term goals. Each year, NSF highlights a number of cross-agency investments in its Budget Request to Congress. Although the overall impact of these investments might not be measurable for many years, tracking near-term indicators of progress can help the agency make formative changes or course corrections.

In FY 2014, NSF successfully monitored the progress of four NSF-wide investments (CEMMSS, CIF21, SaTC, and SEES) using a common set of indicators and reviewed the results with senior leaders. The indicators that NSF chose to measure were programmatic inputs and outputs that can provide valuable signals to managers and leaders about a program's health, such as whether the program is being administered as planned or whether the program is generating enough interest from the community. NSF's process to implement strategic monitoring included working with representatives from the above programs to choose metrics that are compatible with varying organizational and governance structures and with varying subject matter areas. The following metrics were used in FY 2014:

- Input indicator: the investment's funding level.
- Output indicators: solicitations issued, numbers of proposals received, numbers of awards made, funding rate.

These measures enable managers and leaders to quickly gauge the status of a program's implementation, in particular, whether proposals have been received from the scientific community and whether the review process has resulted in awards. The funding rate provides important information about the investment level relative to the number of worthy proposals received. Tracking these measures over time allows managers and leaders to assess whether mid-course corrections are needed to improve program management and/or the overall direction of the investment.

In FY 2015, additional indicators will be monitored each quarter. NSF anticipates that the expanded monitoring will include tracking of short-term outcomes (such as workshops on specific topics) and refinement of input and output measures and milestones (such as funding level by directorate and timely

issuance of solicitations). This expanded monitoring will help ensure that key program investments remain on track for achievement of their goals.

Information on Partial Achievement

At the beginning of FY 2014 reprioritization of FY 2014's investments led to discontinuation of monitoring of INSPIRE and I-Corps™ within this goal.

Goal 5, Improve Undergraduate Education
Lead Organization: Directorate for Education and Human Resources.

Strategic Alignment:

- G1/O2, Integrate education and research to support development of a diverse STEM workforce with cutting-edge capabilities.
- G2/O2, Build the capacity of the Nation to address societal challenges using a suite of formal, informal, and broadly available STEM educational mechanisms.

Fiscal Year	Goal Statement	Target Measure, Milestone, or Deliverable	Result
2014 (new goal)	Establish an NSF-wide undergraduate STEM education program that is evidence-based and evidence-building.	1. By 10/30/2013, perform an environment scan/gap analysis of undergraduate education efforts across NSF using a principle-based framework, and make recommendations for addressing the gaps and overlaps. 2. By 12/31/2013, issue a solicitation for the Catalyzing Undergraduate STEM Education (CAUSE)[4] program. 3. By 9/30/2014, conduct a portfolio analysis of CAUSE[4]-funded projects to summarize the evidence base upon which they rest and the plans they have for building evidence.	All targets achieved.

Discussion
In FY 2014, NSF developed and implemented a framework for a coherent, agency-wide investment approach to achieving the goals for increasing the numbers, broadening the diversity, and improving the preparation of STEM professionals through undergraduate education. The framework focuses investments in three areas: 1) learning and learning environments, 2) workforce development, and 3) broadening participation and building capacity, aligned with the recommendations of the Education and Human Resources Directorate Advisory Committee.[3]

The framework and resulting investment strategies were developed through a three-part process, with progress measured against three targets. In the first phase, NSF gained a better understanding of emphasis areas where its investments were utilized in FYs 2012 and 2013 and how that will change going forward. This was accomplished through an analysis of current investments, accompanied by NSF-wide open meetings to engage the collective expertise of the agency. This analysis informed an agency-wide, principle-based framework for investing in STEM education. The second phase was the release of the NSF Improving Undergraduate STEM Education[4] (IUSE) program description,[5] which received 1,097 proposals in FY 2014. The third phase was an analysis of undergraduate STEM education investments in FY 2014, examining the balance of investments in basic research, applied research, and education and training, with additional discussions across NSF focused on maximizing impact in improving STEM undergraduate education outcomes. This work informed the development of a set of FY 2015 IUSE solicitations focused on improving evidence-based, undergraduate STEM teaching and learning environments for all students, including departmental and institutional transformation.

[3] www.nsf.gov/ehr/Pubs/AC_ReEnvisioning_Report_Sept_2014.pdf
[4] Improving Undergraduate STEM Education (IUSE) was released in lieu of the CAUSE program proposed in the FY 2014 Budget Request, following Congressional action on the NSF budget.
[5] www.nsf.gov/funding/pgm_summ.jsp?pims_id=504976&org=DUE

Goal 6, Enhance National GRFs
Lead Organization: Directorate for Education and Human Resources.

Strategic Alignment:
- G1/O2, Integrate education and research to support development of a diverse STEM workforce with cutting-edge capabilities.

Fiscal Year	Goal Statement	Target Measure, Milestone, or Deliverable	Result
2014 (new goal)	Enhance the Graduate Research Fellowship program to provide a wider range of career development opp-ortunities.	The GRF Program will be enhanced to be a National Graduate Research Fellow-ship (NGRF) Program,[6] a single program for applicants that will provide a wider range of career development opportunities.	Achieved.

Discussion
The GRF program has been considering ways to expand the career development opportunities for its fellows for several years. Two such expansions took place in FY 2014.

- In FY 2014, NSF expanded the Graduate Research Opportunities Worldwide (GROW) program established in 2012 to include career development opportunities. In fall 2012, in conjunction with the 60th anniversary of the fellowship program, GRF announced the launch of the GROW program. GROW provides opportunities for GRF recipients to conduct research-based internships in laboratories and universities in foreign countries. NSF entered into several memoranda of agreement with foreign nations to launch this opportunity. In 2013, NSF received 61 applications and made 53 awards to fellows who conducted research in seven different countries. In FY 2014, GROW partnered with USAID to provide research opportunities in seven developing countries (Brazil and India were in both aspects of GROW). In total, GROW received 176 applications and made 128 awards to fellows who pursued collaborations in 18 countries.
- Also created in FY 2014 was the Graduate Research Internship Program (GRIP), a collaborative opportunity between the GRF program and other federal agencies to permit GRF fellows to participate in internships in federally funded laboratories and agency research sites. By the end of FY 2014, four federal agencies—the Office of Naval Research, the Smithsonian Institution, the Department of Homeland Security, and the Environmental Protection Agency—had signed memoranda of understanding/agreement with NSF to launch this program. The first round of applications to this program will be received in FY 2015.

[6] NSF proposed a National Graduate Research Fellowship Program (NGRF) in the FY 2014 Budget Request. Following Congressional action on the NSF budget, NSF did not establish the NGRF program. NSF instead sought to develop initiatives that were in keeping with the intent of the goal as captured in the goal statement. NSF considers this goal achieved since the GRF program's career development opportunities were measurably enhanced; however, the independent verification and validation (see Other Information in this chapter) considered the goal not achieved due to lack of establishment of the NGRF program.

Goal 7, Career-Life Balance (CLB)
Lead Organization: Office of Integrative Activities.

Strategic Alignment:

- G1/O2, Integrate education and research to support development of a diverse STEM workforce with cutting-edge capabilities.

Fiscal Year	Goal Statement	Target Measure, Milestone, or Deliverable	Result
2014	Promote policies and practices that support more fully utilizing the talents of individuals in all sectors of the American population, principally women, underrepresented minorities, and persons with disabilities.	By 9/30/2014: 1. Conduct a preliminary analysis of the first three years of the CLB initiative that can be used formatively. 2. Conduct outreach activities to increase the awareness of the availability of CLB opportunities (within NSF and in communities where awareness is found to be low). 3. Collaborate with another federal agency to promote career-life balance by developing new ways of partnering with higher education.	All targets achieved. 1. Achieved. Preliminary analysis completed in fourth quarter of FY 2014. 2. Achieved. Outreach conducted, see below for details. 3. Achieved. NIH collaboration underway.
Actual Results for Preceding Fiscal Years			
2013	Promote Career-Life Balance policies and practices that support more fully utilizing the talents of individuals in all sectors of the American population – principally women, underrepresented minorities and persons with disabilities.	By September 30, 2013, 1. Establish the FY 2013 baseline for number and value of awards provided to ADVANCE institutions intended to fund dual career supports. 2. Increase the number and value of research technician award support provided to CAREER awardees and postdoctoral fellows by 10 percent over FY 2012.	One target achieved. 1. Achieved. Baseline established: 18 ADVANCE supplements awarded (total $3.25 million). 2. Not achieved. Number increased under 10 percent (23 to 25), and value of awards decreased ($498,442).
2012	Promote Career-Life Balance policies and practices that support more fully utilizing the talents of individuals in all sectors of the American population – principally women, underrepresented minorities and persons with disabilities.	By September 30, 2012, establish the FY 2012 baseline for number and value of award support provided to CAREER awardees and postdoctoral fellows intended to fund research technicians.	Achieved. Baseline established.[7] 23 supplements were awarded to CAREER awardees, totaling $537,501 for FY 2012.

[7] In FY 2012 NSF reported "20 supplements were awarded to CAREER awardees, totaling $420,355 for FY 2012." In FY 2013, this baseline was adjusted upward when additional awards were found to fit CLB criteria.

Discussion

NSF's Career-Life Balance (CLB) Initiative is designed to develop and promote a coherent set of career-life policies and program opportunities that aim to reduce the rate of departure of early career scientists and engineers from academic careers. In FY 2012, the initiative provided supplemental awards to awardees in the NSF's Faculty Early Career Development program for additional personnel (e.g., research technicians or equivalent) to sustain research when the awardee is on family leave. In FY 2013, the CLB initiative expanded technician support to awardees of the NSF Graduate Research Fellowship program and to postdoctoral fellows supported on any NSF grant and also introduced dual career support through the ADVANCE program.

In FY 2014, the initiative continued funding supplemental grants for technician support while on family leave, developed web-based modules for internal CLB training, disseminated information on the initiative internally and externally, supported international gender summits that included the exchange of ideas and lessons learned about CLB policies and practices, and awarded five grants to higher education institutions to conduct dissemination and outreach activities concerning career-life balance activities and for development and dissemination of best practices, such as extending the tenure clock and dual career opportunities.

In FY 2014, NSF also began collaborating with NIH to harmonize language for family-friendly policies and to have a common set of frequently asked questions and answers for academic institutions. The language is under review and will be published in FY 2015.

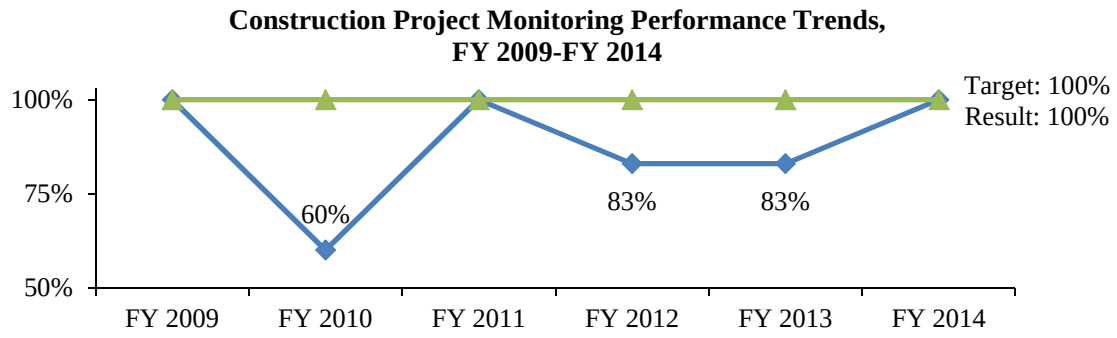
A preliminary analysis of the first three years of the CLB initiative was completed in September 2014 by the contractor Policy Insights. In FY 2015, further evaluation to guide future policy will be conducted through document review, focus groups, and in-depth grantee interviews.

Goal 8, Research Infrastructure Investments
Lead Organization: Large Facilities Office, Office of Budget, Finance, and Award Management.

Strategic Alignment:
- G1/O3, Provide world-class research infrastructure to enable major scientific advances.

Fiscal Year	Goal Statement	Target Measure, Milestone, or Deliverable	Result
2014	Ensure program integrity and responsible stewardship of major research facilities and infrastructure.	Construction Project Monitoring: For all MREFC facilities under construction that are over 10 percent complete, keep negative cost and schedule variance at or below 10 percent.	Achieved. Five of five projects within variances.

Actual Results for Preceding Fiscal Years



Discussion
The Major Research Equipment and Facilities Construction (MREFC) account supports the acquisition, construction, and commissioning of major research facilities and equipment that provide unique capabilities at the frontiers of science and engineering. Performance of construction projects funded by the MREFC account is monitored using the Earned Value Management (EVM) system. EVM is an integrated management control system for assessing, understanding, and quantifying what a contractor or field activity is achieving with program dollars. Monitoring cost and schedule is a standard measure of performance for construction projects. Projects that are under 10 percent complete are not considered eligible for this goal because EVM data is less meaningful statistically in the very early stages of a project.

For more information about the five projects funded from the MREFC account in FY 2014, see the Major Research Equipment and Facilities Construction chapter of this Request.

Goal 9, Diversity and Inclusion
Lead Organization: Office of Diversity and Inclusion, Office of the Director.

Strategic Alignment:

- G3/O1, Build an increasingly diverse, engaged, and high-performing workforce by fostering excellence in recruitment, training, leadership, and management of human capital.

Fiscal Year	Goal Statement	Target Measure, Milestone, or Deliverable	Result
2014	Foster an environment of diversity and inclusion while ensuring compliance with the agency's civil rights programs.	1. Attain six of six essential elements of a model EEO agency. 2. Assist in implementation of one ODI action within NSF's D&I Strategic Plan. 3. Perform two compliance desk reviews under the applicable anti-discrim-ination laws.	1. Not achieved. Four of six essential elements met. 2. Achieved. 3. Not achieved. Reviews not completed in FY 2014.
Actual Results for Preceding Fiscal Years			
2013	Perform activities necessary to attain essential elements of a model EEO agency, as defined by the Equal Employment Opportunity Commission (EEOC).	Attain five of six essential elements.	Achieved. Five elements attained.
2012	Perform activities necessary to attain essential elements of a model EEO agency, as defined by the Equal Employment Opportunity Commission (EEOC).	Attain four of six essential elements. Submit Diversity and Inclusion Strategic Plan to OPM by March 30, 2012.	Achieved. Four elements attained. Plan submitted by deadline.
2011	Attain essential elements of a model Equal Employment Opportunity (EEO) pro-gram, as defined in Equal Employment Opportunity Commission (EEOC) requirements.	Three elements.	Achieved. Three elements obtained.

Discussion
For NSF to attain model EEO agency status, it must meet and maintain each of the six criteria established by the Equal Employment Opportunity Commission (EEOC). The EEOC refers to these criteria as the "Essential Elements" of a Model Agency (see table below). In FY 2014, NSF complied with four of the six essential elements towards attaining a model EEO Agency Program: elements B, C, D, and F.

In 2014, NSF expanded this goal in two ways. First, NSF set a target to attain all of the elements of a model EEO agency—a status no agency has attained. Second, NSF added a target to conduct two desk reviews under Title IX of the Education Amendments of 1972 (hereinafter Title IX), which prohibits

discrimination based on gender in any educational program or activity receiving federal financial assistance.

Explanation of Unmet Goal
Two of the three targets for this goal were not achieved. The first was to attain six of the essential elements of an EEO agency. In FY 2014, two of the six elements were not met: Elements A (demonstrated commitment from agency leadership) and E (efficiency). For more information, see the table of essential elements below.

The target of performing two compliance reviews under the applicable anti-discrimination laws was also unmet in FY 2014. Federal anti-discrimination laws prohibit discrimination in any programs and activities that receive federal funds. Agencies that provide such funding are required to conduct periodic reviews to ensure recipients are in compliance. NSF has not been in compliance with this requirement since 2006 when it conducted one compliance review. This compliance review was conducted after a 2004 report by the Government Accountability Office, which evaluated the participation of women in the sciences and the efforts of four science agencies (Department of Education, Department of Energy, National Aeronautics and Space Administration, and NSF). Since 2009, a number of steps have been taken to bring the agency into compliance, including:

- Drafting a compliance plan, participating with the Title IX Interagency Working Group, and laying the framework for a pro-active and collaborative approach to compliance in which the objectives were to (1) focus on best practices, (2) serve as a resource, and (3) assist recipients in coming into compliance;
- Establishing a Title IX website and publishing the brochure "Nondiscrimination on the Basis of Sex in Federally Funded Programs (Title IX of the Education Amendments of 1972)"; and
- Serving as a Subject Matter Expert for the Large Facilities Business Systems Reviews, which include a component on compliance with anti-discrimination laws and regulations, including Title IX.

In FY 2013, ODI sought funding to establish NSF's compliance program. In FY 2014, ODI received approval for funding to conduct reviews; however, it was not received in time to conduct the two reviews in FY 2014. Also in FY 2014, the position description of ODI's Complaints Manager was revised to reflect the compliance review duties, and NSF and the Department of Energy began laying the foundation to conduct two joint on-site reviews in FY 2015.

EEOC Essential Element Definitions and NSF Activities

Essential Element	NSF Activities
A: Demonstrated commitment from agency leadership requires the agency head to issue a written policy statement ensuring a workplace free of discriminatory harassment and a commitment to equal employment opportunity.	NSF achieved all but two measures under essential element A. The two measures unmet involved ensuring EEO policy statements were current, communicated to all employees, and vigorously enforced by agency management. The revised EEO, and newly devised diversity policy, are under review.
B: Integration of EEO into the agency's strategic mission requires that the agency's EEO programs be organized and structured to maintain a workplace that is free from discrimination in any of the agency's policies, procedures, or practices and	NSF has continued to fully achieve and comply with all of essential element B when it ensured the reporting structure for the EEO program provides the principal EEO official with appropriate authority and resources to effectively carry out a successful EEO program; the EEO Office has a regular and effective means of informing the agency head and senior management officials of the status of EEO programs; the EEO

Essential Element	NSF Activities
supports the agency's strategic mission.	Office is involved in, and is consulted on, management/personnel action; and agency has committed sufficient human resources and budget allocations to its EEO programs to ensure successful operation.
C: Management and program accountability requires the Agency Head to hold all managers, supervisors, and EEO Officials responsible for the effective implementation of the agency's EEO Program and Plan.	NSF achieved compliance with essential element C. NSF has continued to fully achieve and comply with the EEO program officials advising and providing appropriate assistance to managers/supervisors about the status of EEO programs within each manager's or supervisor's area of responsibility. NSF achieved the measure of whether the Human Resources Director and the EEO Director meet regularly to assess whether personnel programs, policies, and procedures are in conformity with instructions contained in EEOC management directives regarding the implementation of schedules to review Merit Promotion Program Policy, Employee Recognition Awards Program, and Employee Development/Training Programs. In meeting these measures, NSF sought guidance from the EEOC during a Federal Sector Complement Review in April 2014.
D: Proactive prevention requires that the Agency Head makes early efforts to prevent discriminatory actions and eliminate barriers to equal employment opportunity in the workplace.	NSF has continued to fully achieve and comply with all of essential element D when it conducts analyses to identify and remove unnecessary barriers to employment throughout the year; and encourages the use of alternative dispute resolution with involvement of senior management.
E: Efficiency requires that there are effective systems in place for evaluation of the impact and effectiveness of the agency's EEO Programs as well as an efficient and fair dispute resolution process.	NSF met all but three measures under element E when it provided sufficient staffing, funding, and authority to achieve the elimination of identified barriers; provided an effective complaint tracking and monitoring system to increase the effectiveness of the agency's EEO programs; provided sufficient staffing, funding, and authority for processing EEO complaints of employment discrimination; provided an effective and fair dispute resolution process and effective systems for evaluating the impact and effectiveness of the agency's EEO complaint processing program; and implemented effective systems for maintaining and evaluating the impact and effectiveness of its EEO programs. Areas of improvement include ensuring counseling is complete in a timely manner, investigations are conducted within the applicable timeframes and that the management officials involved in a dispute have actual settlement authority.
F: Responsiveness and legal compliance requires that federal agencies are in full compliance with EEO statutes and EEOC regulations, policy guidance, and other written instructions.	NSF has continued to fully achieve and comply with all of essential element F when the agency's system of management controls ensures that the agency completes all ordered corrective actions in a timely manner and submits its compliance report to EEOC within 30 days of such completion; and agency personnel are accountable for the timely completion.

Goal 10, Evidence-Based Reviews
Lead Organization: Office of Information and Resource Management

Strategic Alignment:
- G3, Excel as a Federal Science Agency

Fiscal Year	Goal Statement	Target Measure, Milestone, or Deliverable	Result
2014 (new goal)	Use evidence-based reviews to guide management investments.	HRStat measures: 1. Develop a human capital management dashboard to report progress toward human capital (HC) goals and to monitor HC metrics, for use as an internal resource for informing investment decisions. 2. Establish a review process which culminates in quarterly reviews of HC metrics by senior management and which incorporates, to the extent possible, OPM's human capital accountability system requirements. PortfolioStat measures: 3. NSF's IT governance boards will evaluate and prioritize proposed investments for FY 2016. 4. NSF will move toward a standardized computing environment, reducing purchase costs by $300,000 below FY 2012 levels by FY 2014. 5. Migration to cloud email provider will reduce costs by approximately $240,000 below FY 2012 levels by FY 2014.	1. Achieved. Dashboard released in FY 2014. 2. Achieved. Review process established. 3. Achieved. Governance boards prioritized IT portfolio. 4. Achieved.[8] Costs reduced by at least $376,725. 5. Achieved.[8] Costs reduced by $260,000.

Discussion
HRStat and PortfolioStat are processes in which agency leaders conduct regular data-driven reviews of human resources or IT portfolio information.

HR Stat: Targets 1 and 2
In FY 2014, NSF developed a first-generation human capital management dashboard for senior management use. The dashboard includes Federal Employee Viewpoint Survey measures and internal HR data and provides information on four human capital focus areas. These areas are subject to change as topics are identified or deemphasized by leadership. The FY 2014 focus areas are:
- *Monitor NSF Retention*. NSF is concerned about an impending acceleration of retirements due to the forthcoming NSF relocation, especially among the Senior Executive Service (SES) cadre. NSF understands the knowledge management challenges and those associated with the time required to fill executive positions. The dashboard provides historical loss rates data and losses by directorate, and allows dashboard users to drill into divisions to see what types of employees are leaving and in what numbers.

[8] These results were not available in time for the FY 2014 verification and validation process. They will be V&V'd in FY 2015 and any corrections published in the FY 2015 APR.

- *Create Viable Career Paths*. NSF is looking for opportunities to create more viable career paths for both scientific and non-scientific positions, for which, historically, NSF has not had clearly defined career paths. In addition, NSF has not made significant use of science positions outside of AD-4 Program Officers. However, given changes to NSF work, there may be new opportunities to create positions other than Program Officers within scientific disciplines and more clearly define possible career progressions for non-scientific staff. The dashboard provides data regarding employee attitudes about career progression opportunities at NSF as well as data about the number and types of hires it makes each year.
- *Enhance Recruitment Efforts*. NSF's high retirement eligibility, particularly among those in senior positions, along with the lengthy hiring process compel the agency to look at the number and types of positions being hired as well as the processes for hiring. The dashboard provides data about the number of executive hires each year and the amount of time it takes to recruit/select/onboard employees into those executive positions.
- *Level Workload*. Workload at NSF has been an ongoing issue and most directorates/offices have projected an increase in workload between now and FY 2016. Workload challenges have resulted from flat FTE allocations, increased oversight and regulatory requirements, and increases in the amount of crosscutting (i.e., cross-discipline) work in the program directorates involving initiatives with other directorates, often necessitating broader skills. The dashboard provides data about workload, including employee perceptions of workload.

NSF's HR data review process is built into the GPRA quarterly review process and incorporates OPM requirements to the extent possible at each review.

Portfolio Stat: Target 3

In order to strengthen its IT investment evaluation process and ensure NSF's IT investments best support the Foundation's business needs, NSF implemented a more formal and disciplined IT investment review and decision-making process. Specifically, NSF strengthened its process for approving centrally-funded IT investments by requiring advocates for new IT investments to complete detailed justification and business case documentation. This ensures that advocates for new IT investments have fully considered the business need, benefits, impacts, and strategic alignment of each potential investment. This also helps the CIO and governance boards verify that IT, rather than policy changes or business process reengineering, is the appropriate solution to a business need, and it provides NSF's CIO and governance boards the information needed to review, approve, and prioritize investment proposals using a comprehensive evaluation methodology. This process was successfully used to prepare the FY 2016 IT budget request and prioritize an $80+ million investment portfolio.

Portfolio Stat: Targets 4 and 5

NSF has undertaken several initiatives to reduce the costs of the computing environment.

- *Desktop and Laptop Procurement.* NSF awarded a Blanket Purchase Agreement (BPA) with a companion catalog ordering tool to support the purchase of desktops and laptops for use by all organizations. This allows NSF to leverage ordering activities' buying power by taking advantage of quantity discounts, saves administrative time, and reduces paperwork. These tools provide a means to easily order all desktops and laptops via a standard set of requirements using one procurement vehicle. This initiative will help NSF to reduce the number of desktop configurations to be supported and reduce outyear support costs. Savings in this area have not been calculated for FY 2014 since purchasing is accomplished within each organization. NSF expects to realize benefits in the outyears; as the number of desktop configurations decrease, labor to support the desktop configurations will decrease.
- *Mobile Device Management*. NSF awarded a Telecommunications Expense Management (TEMS) contract in 2012 with the goal of improving management of mobile devices and their associated plans

resulting in reduced wireless costs. In 2013, a pilot was launched with approximately 50 percent of NSF lines participating. The TEMS provider identified that NSF had been overbuying minutes and data plans, was maintaining a substantial number of zero-use devices, and received inaccurate carrier invoices and other items that contributed to mobile device costs. An estimated savings of $167,000 has been identified via optimization and validation exercises across the Foundation (mobile devices are funded within each of the directorates).

- *Laptop Rentals*. NSF has reduced cost of laptop rentals in support of panels by migrating to a virtual laptop model which requires a less costly laptop to support. In FY 2012 NSF spent $717,042 and in FY 2014 NSF spent $507,317 for a reduction of $209,725.
- *Cloud Email*. One of NSF's Portfolio Stat initiatives was to migrate existing local based email services to a cloud based solution. The project was initiated in 2012 and successfully implemented in 2013. After an initial successful pilot program all email was converted to the cloud based solution. As a part of the migration NSF was able to realize a cost savings as a result of no longer needing to support the local hardware infrastructure and its associated maintenance and support costs. As an additional longer term benefit, upgrades to future versions of our email platform will require much less cost and will be implemented seamlessly across the Foundation. As reported to OMB via the Integrated Data Collection (IDC), in 2012 the annual cost of email was $700,000 and in 2014 the cost was $440,000, resulting in a savings of $260,000.

Goal 11, Financial System Modernization
Lead Organization: Office of Budget, Finance, and Award Management.

Strategic Alignment:

- G3/O2, Use effective methods and innovative solutions to achieve excellence in accomplishing the agency's mission.

Fiscal Year	Goal Statement	Target Measure, Milestone, or Deliverable	Result
2014	Upgrade NSF's financial system.	Manage cost and schedule variance of the iTRAK system integrator within +/- 10 percent of the baseline.	Achieved. Cost and schedule variances for FY 2014 were zero.
Actual Results for Preceding Fiscal Years			
2013	Upgrade NSF's financial system.	By September 30, 2013, to support the transition to the grant-by-grant payment process known as the Award Cash Management $ervice (ACM$), DFM will reconcile 100 percent of the grantee's reported cash on hand balances as of December 31, 2012 with NSF's general ledger.	Achieved. All grantees were transferred to ACM$ by June 30, 2013.
2012	Upgrade NSF's financial system.	By September 30, 2012, to support the iTRAK initiative, the Division of Financial Management (DFM) and the Division of Acquisition and Cooperative Agreements (DACS) will award a contract for the iTRAK financial system implementation and integration services.	Achieved. Contract awarded September 25, 2012.

Discussion
Financial system modernization efforts have been underway at NSF for several years and culminated with the deployment of iTRAK in October 2014. iTRAK is a fully integrated, commercial-off-the-shelf (COTS) financial management shared services solution. One of NSF's FY 2014 goals was to manage the cost and schedule variance of the iTRAK system integrator (SI) within +/- 10 percent of the performance measurement baseline.

Each month, the SI submitted a project performance report to NSF showing the cost and schedule variance of the iTRAK implementation project. Throughout 2014, the variances were consistently well below 10 percent, which indicated that the project was within an acceptable level of being on schedule and on budget. At the end of the year, there was no cost or schedule variance. The SI deployed iTRAK without a cost or schedule overrun.

Goal 12, Customer Service: Time To Decision
Lead Organization: Office of Integrative Activities.

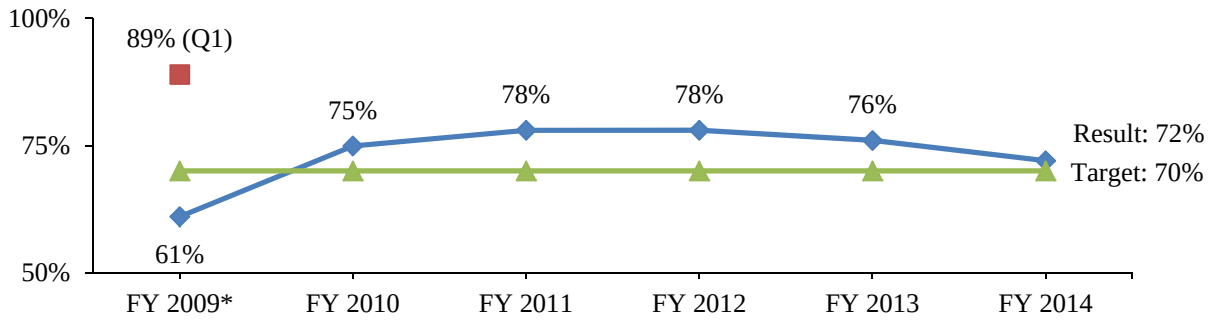
Strategic Alignment:

- G3/O2, Use effective methods and innovative solutions to achieve excellence in accomplishing the agency's mission.

Fiscal Year	Goal Statement	Target Measure, Milestone, or Deliverable	Result
2014	Inform applicants whether their proposals have been declined or recommended for funding within 182 days, or six months, of deadline, target, or receipt date, whichever is later.	70 percent.	Achieved. 72 percent.

Actual Results for Preceding Fiscal Years

Time to Decision Performance Trends, FY 2009-FY 2014



*In FY 2009, this goal was in effect only for the period October 1 through December 31, 2008 (Quarter 1, FY 2009). The goal was suspended for all actions taking place between January 1, 2009 and September 30, 2009 to allow for a greater number of proposals to be processed with the additional funds from the American Recovery and Reinvestment Act of 2009 (ARRA).

Discussion

Time to decision or "dwell time" is the amount of time that passes between receipt of a proposal and notification to the principal investigator about the funding decision. One of the most significant issues raised in customer satisfaction surveys is the time it takes NSF to process proposals. Too long a time period inhibits the progress of research as it delays the funding process, but too short a time period may inhibit the merit review process. The six-month target seeks to strike a balance between the need of the investigator for timely action and the need of NSF for a credible and efficient merit review system.

While NSF exceeded the target in FY 2014, it did so by a historically low margin. This is likely due to Foundation-wide delays in proposal processing after the lapse in funding authority in October 2013. This reduction is the most significant variation since FY 2009, when the goal was suspended after the first quarter to allow for a greater number of proposals to be processed with additional funds from ARRA.

Goal 13, Virtual Merit Review Panels
Lead Organization: Office of Integrative Activities, Office of the Director.

Strategic Alignment:
- G3/O2, Use effective methods and innovative solutions to achieve excellence in accomplishing the agency's mission.

Fiscal Year	Goal Statement and Target	Target Measure, Milestone, or Deliverable	Result
2014	Improve the ability to use virtual merit review panels by incorporating technological innovations into review process.	15 percent of merit review panels will be wholly virtual panels.	Achieved. 31.2 percent of panels were virtual panels.
Actual Results for Preceding Fiscal Years			
2013	Expand the use of virtual merit review panels.	As a pilot activity, five percent of merit review panels will be virtual panels.	Achieved. 28.6 percent of panels were virtual panels.
2012	Expand the use of virtual merit review panels.	By September 30, 2012, develop guidelines and training modules for NSF staff on the use of virtual merit review panels.	Achieved. Training modules developed.

Discussion
NSF makes extensive use of panels of reviewers to evaluate proposals. The predominant practice is for the panelists to travel to a single location, usually NSF, and meet face-to-face for one to five days. In FY 2010, approximately 2,100 review panels were held. Of these, just over one quarter involved six or fewer panelists. Face-to-face panels impose a significant time burden on the reviewers, making some potential reviewers reluctant to participate. For example, panelists with young children may not be able to obtain two continuous days of childcare, or panelists in remote locations or foreign countries may find the amount of travel required prohibitive. It also causes NSF to incur significant travel costs.

As used in reference to this goal, the term "virtual panel" refers to a panel meeting in which the reviewers do not travel to a common location but instead participate via teleconference, videoconference, or an online meeting technology. NSF has experimented with virtual panels at a small scale for several years. In FY 2011, approximately 2.2 percent of panels were virtual panels, and approximately one percent of proposals that were reviewed by panels were reviewed by virtual panels.

In FY 2014, administrative offices and program staff collaborated to complete the first three of a planned set of four training modules for organizers of virtual panels at NSF. An internal website provides guidance to NSF staff on when to choose a virtual panel and how best to implement such panels was also developed and numerous outreach activities such as town hall meetings were conducted to familiarize staff with the resources available to them.

In FY 2012, 99 virtual panels were conducted. In FY 2013, 1,874 panels were held, of which 537 were wholly virtual (28.6 percent), exceeding the FY 2013 target of five percent wholly virtual panels. In FY 2014 a total of 1,292 panels were held of which 587 were wholly virtual (31.2 percent), exceeding the FY 2014 goal of 15 percent of wholly virtual panels. This significant increase in virtual participation over prior years can be attributed to several factors: a response to reductions in travel budgets; development of

virtual panel training materials; and management's encouragement to utilize virtual panels as a viable reviewer participation mechanism. A virtual panelist survey administered to participating virtual panelists is being used to inform NSF's virtual panel process. Three of four planned virtual panel training modules have now been completed, with the fourth expected to be completed in FY 2015.

FY 2016 ANNUAL PERFORMANCE PLAN

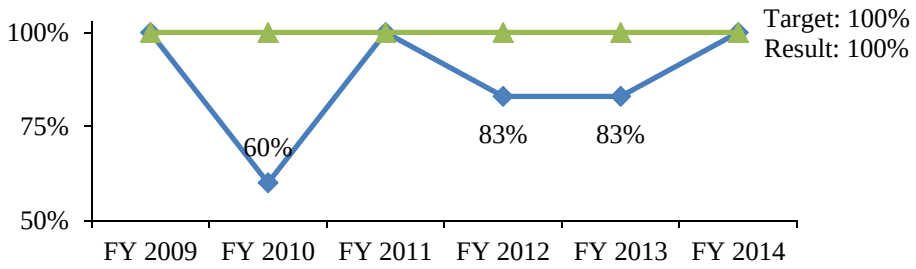
NSF's FY 2016 Performance Plan reflects NSF's priorities as identified through its planning and budget process. The table below provides a summary of NSF's performance goals for FY 2016. The remaining pages of this section provide a detailed description of each goal along with the proposed target measures, milestones, or deliverables.

ID	Goal Short Title	Lead Organization	Goal Statement
1	Ensure that Key Program Investments are on Track	BFA	Ensure that key FY 2016 NSF-wide program investments are implemented and on track.
2	Ensure that Infrastructure Investments are on Track	BFA	Ensure program integrity and responsible stewardship of major research facilities and infrastructure.
3	Use Evidence to Guide Decisions	OIRM	Use evidence-based reviews to guide management investments.
4	Make Timely Award Decisions	OIA BFA	Inform applicants whether their proposals have been declined or recommended for funding within 182 days, or six months, of deadline, target, or receipt date, whichever is later.
5	Foster an Environment of Diversity and Inclusion	ODI	Foster an environment of diversity and inclusion while ensuring compliance with the agency's equal opportunity and civil rights programs.
6	Evaluate NSF Investments	OIA	Enable consistent evaluation of the impact of NSF investments with a high degree of rigor and independence.
7	Increase the Percentage of Wholly Virtual Panels	CTO and OIA	Increase the percentage of proposal review panels that are conducted wholly virtually while maintaining the quality of the merit review process.

Goal 1: Ensure that Key Program Investments are on Track

Goal Statement	Ensure that key FY 2016 NSF-wide program investments are implemented and on track.
Indicator and Target Measure, Milestone, or Deliverable	1) Monitor the progress of the following NSF-wide investments using a common set of milestones and indicators: NSF INCLUDES, INFEWS, and UtB. 2) Review the results with senior leaders quarterly in data-driven performance reviews.
Description	Key investments will be strategically monitored using a set of common metrics. These may include: • Contextual indicators, such as the investment's funding level. • Input indicators, such as date of release of solicitation, number of proposals received, numbers of reviews conducted. • Output indicators, such as number of awards, average and total amounts awarded, and funding rate. • Medium-term output and outcome indicators that gauge whether funded projects are on track. • Activity-specific outcome indicators, e.g., those relating to programmatic long-term goals to change a given field. Progress will be assessed with quarterly review meetings to discuss progress and annual Strategic Reviews.
Trend Information	This was a new goal in FY 2014. In FY 2014 NSF monitored the implementation and progress of CIF21, CEMMSS, SaTC, and SEES. For more information on those goals, refer to the FY 2014 Annual Performance Report.
Strategic Alignment	Strategic Goal G1: Transform the Frontiers of Science and Engineering, all Objectives. Strategic Goal G2: Stimulate Innovation and Address Societal Needs through Research and Education, all Objectives.
Lead Organization/s	Office of Budget, Finance, and Award Management

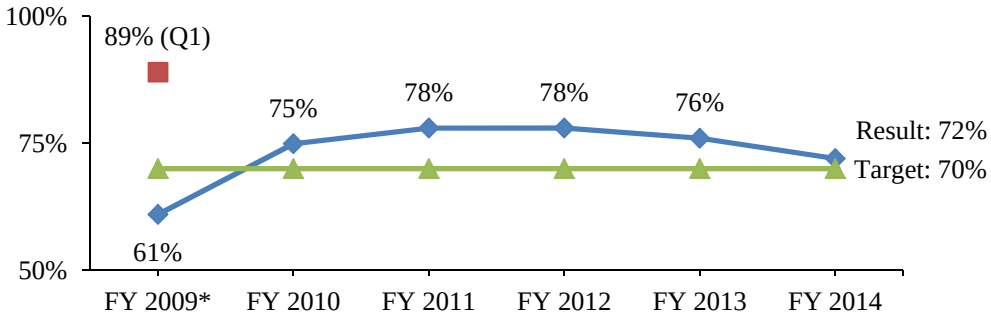
Goal 2: Ensure that Infrastructure Investments are on Track

Goal Statement	Ensure program integrity and responsible stewardship of major research facilities and infrastructure.
Indicator and Target Measure, Milestone, or Deliverable	Construction Project Monitoring: For all Major Research Equipment and Facilities Construction (MREFC) facilities under construction that are over 10 percent complete, keep negative cost and schedule variance at or below 10 percent.
Description	NSF monitors the performance of projects funded by the MREFC account by monitoring cost and schedule, a standard measure of performance for construction projects. Projects that are under ten percent complete are not considered eligible for this goal because Earned Value Management (EVM) data is statistically less meaningful in early stages.
Trend Information	**Construction Project Monitoring Performance Trends, FY 2009-FY 2014** 
Strategic Alignment	Strategic Goal G1: Transform the Frontiers of Science and Engineering**,** Objective O3: Provide world-class research infrastructure to enable major scientific advances.
Lead Organization/s	Large Facilities Office, Office of Budget, Finance, and Award Management

Goal 3: Use Evidence to Guide Management Decisions

Goal Statement	Use evidence-based reviews to guide management investments.
Indicator and Target Measure, Milestone, or Deliverable	PortfolioStat measures: • NSF's information technology governance boards will evaluate and prioritize proposed investments for FY 2017. • NSF's information technology governance boards will use cost and schedule data for ongoing investments to inform investment decisions for FY 2018. HRStat measures: • Establish indicators to assess progress of three workforce initiatives designed to meet the objectives of the Opportunities for Action in NSF's FY 2014 Strategic Review for Strategic Goal 3, Objective 1. • During FY 2016, focus at least two evidence-based reviews on the three identified workforce initiatives.
Description	This goal captures NSF's commitment to two government-wide processes, PortfolioStat and HRStat, which aim to ensure that decisions regarding resource investments are made through formal processes involving cross-agency decision-makers. Data regarding business need, cost, and risk-analysis will be provided. This approach to decision making promotes transparency and accountability through data driven decision-making. As directed in OMB M-12-10, "Implementing PortfolioStat," NSF will employ this new tool to assess the current maturity of its IT portfolio management process, make decisions on eliminating duplication, augment current Chief Information Officer (CIO)-led capital planning and investment control processes, and move to shared solutions in order to maximize the return on IT investments across the portfolio. NSF will build upon its experience as a HRStat pilot in 2012-2013, incorporate lessons learned from the development of its human capital dashboard, and continue to update and refine its evidence based review process (incorporating it into the Strategic Review process), as it establishes indicators and methods to measure human capital management initiatives aligned with the goals set out in the NSF Strategic Plan.
Trend Information	Since FY 2011, the Office of the Chief Human Capital Officer (CHCO) has led three performance goals per year relating to human resources development. For more information about those goals, refer to the Annual Performance Reports for those years.
Strategic Alignment	Strategic Goal G3: Excel as a Federal Science Agency, all Objectives.
Lead Organization/s	Office of the CIO and Office of the CHCO, Office of Information and Resource Management

Goal 4: Make Timely Award Decisions

Goal Statement	1) Inform applicants whether their proposals have been declined or recommended for funding in a timely manner.
Indicator and Target Measure, Milestone, or Deliverable	1) Inform 75 percent of applicants whether their proposals have been declined or recommended for funding within 182 days, or six months, of deadline, target, or receipt date, whichever is later;
Description	Time-to-decision or "dwell time" is the amount of time that passes between receipt of a proposal and notification to the principal investigator about the funding decision. One of the most significant issues raised in customer satisfaction surveys is the time it takes NSF to process proposals. Too long a time period inhibits the progress of research as it delays the funding process, but too short a time period may inhibit the merit review process.
Trend Information	NSF has tracked this measure as a performance goal for over a decade and has consistently met a six month target of 70 percent. In FY 2014 the six month target was increased to 75 percent, and NSF met the increased target. **Time to Decision Performance Trends, FY 2009-FY 2014**  *In FY 2009, this goal was in effect only for the period October 1 through December 31, 2008 (Quarter 1, FY 2009). The goal was suspended for all actions taking place between January 1, 2009 and September 30, 2009 to allow for a greater number of proposals to be processed with the additional funds from the American Recovery and Reinvestment Act of 2009 (ARRA).
Strategic Alignment	Strategic Goal G3: Excel as a Federal Science Agency, Objective O2: Use effective business methods and innovative solutions to achieve excellence in accomplishing the agency's mission.
Lead Organization/s	Office of Integrative Activities, Office of the Director. Office of Budget, Finance, and Award Management.

Goal 5: Foster an Environment of Diversity and Inclusion

Goal Statement	Foster an environment of diversity and inclusion while ensuring compliance with the agency's equal employment opportunity and civil rights programs.
Indicator and Target Measure, Milestone, or Deliverable	• Continue to perform as a model EEO agency. • Assist in implementation of two ODI actions within NSF's D&I Strategic Plan. • Perform two compliance reviews.
Description	NSF's diversity and inclusion goal has several components. • For NSF to achieve model EEO agency status in a given year, it must meet and maintain each of the six criteria established by the EEOC. The EEOC refers to these criteria as the "Essential Elements" of a Model Agency, which are: 1. Demonstrated commitment from agency leadership; 2. Integration of EEO into the agency's strategic mission; 3. Management and program accountability; 4. Proactive prevention of unlawful discrimination; and 5. Responsiveness and legal compliance. NSF's activities have been aimed towards attainment of Model EEO status for several years and it will continue its efforts to obtain this goal. • The Office of Diversity and Inclusion (ODI) will work collaboratively with the NSF Chief Human Capital Officer (CHCO) and the Office of Human Resource Management in implementing NSF's first D&I Strategic Plan focusing on specific areas of engagement and in fostering a diverse and inclusive work environment. ODI will continue to identify processes and mechanisms for effective implementation of NSF's D&I Strategic Plan. • Title IX of the Education Amendments of 1972 (hereinafter Title IX) prohibits discrimination based on gender in any educational program or activity receiving federal financial assistance. Additionally, ODI's compliance program will include desk and on-site reviews to ensure recipients are in compliance under Title IX. NSF is also implementing regulations to ensure that educational programs that receive NSF funds are free of gender discrimination and harassment. (45 C.F.R. § 618). NSF's regulations under Title VI of the Civil Rights Act of 1964 incorporates NSF's Title IX compliance responsibilities, which require the agency to conduct periodic review of recipient practices to determine if they are in compliance. NSF has adopted a philosophy that involves serving as a resource to grantees while maintaining a balance of identifying and reporting on "career-life" best practices and ensuring full compliance. NSF's process will involve educating its stakeholders on the roles and responsibilities under Titles IX and VI as well as NSF's specific compliance process, which includes a strong communication strategy to all stakeholders, inclusive of NSF's internal staff and grantees.

Goal 5: Foster an Environment of Diversity and Inclusion (continued)

Goal Statement	Foster an environment of diversity and inclusion while ensuring compliance with the agency's equal employment opportunity and civil rights programs.
Description (continued)	For compliance reviews, NSF will use collaborative approaches that are modeled specifically for its programs and adopted from effective proven models for conducting annual desk and site reviews as part of its risk assessment as well as its Business Systems Review processes. Similar to these models, NSF's compliance process will involve: making neutral, nonrandom selections for review, based on criteria which may include the amount of financial assistance, the location and size of the institution, the demographic composition of the science and math programs granted, the potential impact of a review, and the recentness of a compliance review; engaging and collaborating with recipients; assisting in ensuring basic compliance; and focusing on best practices. NSF's compliance model will also involve conducting desk reviews to gather preliminary compliance information in which participants will be selected based on neutral criteria referenced earlier. NSF will request information needed to evaluate whether a recipient's policies, procedures, and practices are consistent with Title IX and Title VI requirements, NSF's regulations, and other relevant guidelines.
Trend Information	NSF has been tracking its progress towards Model EEO Agency status as a performance goal since FY 2011. In FY 2011, NSF exceeded its baseline goal of three elements by attaining four of six elements. In FY 2012 and FY 2013, five of six elements were attained. In FY 2014, four of six elements were achieved.
Strategic Alignment	Strategic Goal G3: Excel as a Federal Science Agency, all Objectives.
Lead Organization/s	Office of Diversity and Inclusion, Office of the Director

Goal 6: Evaluate NSF Investments

Goal Statement	Enable consistent evaluation of the impact of NSF investments with a high degree of rigor and independence.
Indicator and Target Measure, Milestone, or Deliverable	By September 30, 2016, the NSF Evaluation and Assessment Capability (EAC) will have updated its evaluation quality principles and disseminated them to all directorates. These quality principles will be followed by all new evaluation projects across the agency. NSF will have incorporated logic models/theory of change language in the rationale for all new programs (expected outputs and outcomes).
Description	The mission of the EAC is to enable NSF to consistently evaluate the impacts of its investments, make more data-driven decisions, and establish a culture of evidence-based planning and policy-making. Before EAC, all evaluation activities were managed within the directorate of the program being evaluated with little centralized coordination. Although the distributed approach allows for the input of local program knowledge, there are significant advantages to building evaluation capacity centrally in order to promote rigor, integrate evaluation into performance management, and ensure that the results of evaluation are consistently used to inform decisions. While directorates and offices will continue to manage their respective program evaluations, EAC will provide foundation-wide leadership and coordination, providing a set of quality principles and evaluation policies applicable NSF-wide that will assure consistency and the best use of evaluation dollars. This includes EAC coordination of NSF cross-cutting programs and initiatives. EAC has made progress exploring the frontier in evaluation of research investments with national experts convened in a series of workshops to inform a framework that establishes levels of evidence and rigor for different types of programs, including basic research programs. The EAC piloted a peer review mechanism for statements of work and evaluation designs against evaluation quality principles. EAC has also clarified roles and responsibilities for an integrated evidence-based system for decision-making, formation of the internal evaluation working group, and establishing mechanisms to design and supervise cross-cutting evaluations. A national leader to head the EAC and additional staff will be in place in FY 2015.
Trend Information	This performance goal was new in FY 2015.
Strategic Alignment	Strategic Goal 1: Transform the Frontiers of Science and Engineering, all Objectives. Strategic Goal 2: Stimulate Innovation and Address Societal Needs through Research and Education, all Objectives. Strategic Goal 3: Excel as a Federal Science Agency, all Objectives.
Lead Organization/s	Office of Integrative Activities, Office of the Director

Goal 7: Increase the Percentage of Wholly Virtual Panels.

Goal Statement	Increase the percentage of proposal review panels that are conducted wholly virtually while maintaining the quality of the merit review process.
Indicator and Target Measure, Milestone, or Deliverable	At least 40 percent of merit review panels will be wholly virtual panels.
Description	The merit review process is NSF's most critical business function. Increased proposal submissions without attendant increases in staff have resulted in increased workload for staff and reviewers. Virtual panels can be an effective mechanism to improve efficiency.
Trend Information	This is a new goal in FY 2016. Earlier performance goals to improve the efficiency of proposal review encouraged virtual panels as a potential mechanism.
Strategic Goal Linkage, FY 2014-FY 2018 Strategic Plan	Strategic Goal: "Excel as a Federal Science Agency" Strategic Objective: "Use effective business methods and innovative solutions to achieve excellence in accomplishing the agency's mission."
Lead Organization/s	NSF Chief Technology Officer (CTO) Office of Integrative Activities

OTHER INFORMATION

Management Reviews
Each quarter, NSF senior leadership reviews progress towards all performance goals of the agency in a data-driven review meeting led by the Chief Operating Officer and Performance Improvement Officer. While focus is on the quarterly performance of the priority goals, all of the agency's goals are discussed.

Alignment of Human Capital Efforts with Organizational Performance
NSF requires all employees, executives, and the general workforce to set individual goals aligned with the Foundation's mission and strategic goals in order to drive individual and organizational performance. NSF provides training and makes tools and templates available for all supervisors and employees on linking performance plans to agency mission, as well as providing assistance and training on the policies, processes, requirements, and timeframes for the development of performance plans and appraisals.

NSF also directly aligns its strategic human capital and accountability efforts to the agency goals identified in the NSF Strategic Plan. Agency performance goals currently outline specific human capital goals, and NSF uses HRStat as the agency reporting mechanism to articulate the nexus between NSF's strategic goals/objectives, including agency performance goals, and human capital initiatives at the agency. Senior leaders are briefed quarterly regarding the status of agency performance goals and the human capital initiatives aligned to those goals.

Strategies and Collaborations
No one standard strategy is used across NSF for achievement of goals. Goal leaders at NSF choose strategies tailored to their stakeholders' needs and their institutional capabilities. NSF goals often involve testing the impacts of new activities or new approaches to existing activities, so feedback mechanisms are built in. Use of analysis, evidence, and evaluation findings is also at the discretion of each individual goal leader, as is the decision to collaborate with other agencies or external entities or to invest in contract support for their activities. Performance at NSF is reviewed quarterly by NSF's Performance Improvement Officer, who reports on goal progress to NSF senior management.

NSF employs a balanced set of performance indicators, milestones, and measures. Due to the nature of NSF investments, the two mission-oriented goals, *Transform the Frontiers of Science and Engineering* and *Stimulate Innovation and Address Societal Needs through Research and Education*, tend to be output- or outcome-based. The management-oriented goal, *Excel as a Federal Science Agency*, contains efficiency and customer-service measures, but also output and outcome measures relating to long-term activities such as strategic human capital management and diversity and inclusion.

Advisory Committees and Committees of Visitors
Each directorate and office has an external advisory committee that typically meets twice a year to review and provide advice on program management, discuss current issues, and review and provide advice on the impact of policies, programs, and activities in the disciplines and fields encompassed by the directorate or office. In addition to directorate and office advisory committees, NSF has several committees that provide advice and recommendation on specific topics: astronomy and astrophysics; environmental research and education; equal opportunities in science and engineering; direction, development, and enhancements of innovations; polar programs; advanced cyberinfrastructure; international and integrative activities; the agency's merit review processes; and business and operations.

Committees of Visitors (COVs) are subcommittees of NSF directorate advisory committees. COV reviews provide NSF with external expert judgments in two areas: (1) assessments of the quality and integrity of program operations and program-level technical and managerial matters pertaining to proposal decisions; and (2) comments on how the outputs and outcomes generated by awardees have

contributed to the attainment of NSF's mission and strategic outcome goals. COV reviews are conducted at regular intervals of approximately three years for programs and offices that recommend or award grants, cooperative agreements, and/or contracts and whose main focus is the conduct or support of NSF research and education in science and engineering. Approximately one-third of NSF's divisions are assessed each year.

A COV typically consists of up to 20 external experts, selected to ensure independence, programmatic coverage, and geographic balance. COV members come from academia, industry, government, and the public sector. They meet for two or three days to review and assess program priorities, program management, and award accomplishments or outcomes. Each COV prepares a report and the division or program that is being reviewed must prepare a response to the COV recommendations. These reports and responses are submitted to the parent advisory committee and to the Director of NSF. All reports and responses are public and posted on NSF's website at: www.nsf.gov/od/oia/activities/cov/covs.jsp.

In FY 2014, five directorates convened 10 Committees of Visitors (COVs), covering seven divisions and three programs. A list of the COVs performed is provided below. The chapters of the directorates also contain information on these COVs, as well as information on *ad hoc* reports.

Other Information

List of Committees of Visitors Meetings, FY 2012-FY 2016

DIR	FY 2012	FY 2013	FY 2014	FY 2015 (planned)	FY 2016 (planned)
BIO	Environmental Biology	Biological Infrastructure: Plant Genome Research Program	• Molecular and Cellular Biosciences • Integrative Organismal Systems • Emerging Frontiers	Environmental Biology	Biological Infrastructure
CISE	-	-	-	• Computing and Communication Foundations • Computer and Network Systems • Information and Intelligent Systems	-
EHR	Graduate Education: GRFs Research on Learning in Formal and Informal Settings: • DR K-12 • REESE • GSE • RDE Undergraduate Education: • ATE • Noyce	Human Resource Development: • AGEP • CREST • HBCU-UP • LSAMP • TCUP Undergraduate Education: • STEP • TUES	Human Resource Development: ADVANCE	Research on Learning in Formal and Informal Settings: all programs Graduate Education: Integrative Graduate Education and Research Traineeship (IGERT) Undergraduate Education: multiple programs	Human Resource Development: • AGEP • CREST • HBCU-UP • LSAMP • TCUP Monitoring Data Collection, Analysis, and Storage
ENG	• Chemical, Bioengineering, Environmental and Transport Systems (CBET) • Civil, Mechanical and Manufacturing	• Engineering, Education and Centers (EEC) • Industrial Innovation and Partnerships (IIP)	• Electrical, Communications and Cyber Systems • Emerging Frontiers in Research and Innovation	• CBET • CMMI	• EEC • IIP

DIR	FY 2012	FY 2013	FY 2014	FY 2015 (planned)	FY 2016 (planned)
	Innovations (CMMI)				
GEO	Atmospheric & Geospace Sciences: Lower Atmospheric Facilities Oversight Section Earth Sciences: Deep Earth Processes Section Ocean Sciences: • Integrative Programs Section • Marine Geosciences Section • Ocean Section	Atmospheric and Geospace Sciences: Lower Atmosphere Research Section Earth Sciences: Instrumentation and Facilities Polar Programs: • Antarctic Infrastructure & Logistics • Antarctic Sciences • Arctic Sciences Education and Diversity programs	Atmospheric and Geospace Sciences: Geospace Section Earth Sciences Ocean Sciences: Integrative Programs Section	Atmospheric & Geospace Sciences: NCAR and Facilities Section Ocean Sciences: Research and Education	Atmospheric and Geospace Sciences: Atmosphere Section Polar Programs: • Antarctic Infrastructure & Logistics • Antarctic Sciences • Arctic Sciences
MPS	Physics	• Chemistry • Mathematical Sciences	-	• Astronomy • Materials Research • Physics	-
SBE	Office of Multidisciplinary Activities (OMA)	• Behavioral and Cognitive Sciences (BCS) • Social and Economic Sciences	-	OMA	BCS
OIA/ OIIA	Experimental Program to Stimulate Competitive Research (EPSCoR)	-	International Science and Engineering	EPSCoR	Science and Technology Centers

Evaluations and Research

Evaluations at NSF are currently performed at the discretion of the individual directorate, office, or program being evaluated. For discussion of how NSF uses planned, current, and recently completed evaluations in its program decisions, refer to individual directorate and office chapters. A list of the evaluations completed in FY 2014 follows, along with a list of selected high-impact events (workshops, symposia, or other meetings resulting in publications) reported by directorates. For more details about how the results of these specific evaluations or events are being used to shape agency decisions, see the chapter of the sponsoring directorate. For more information about program evaluation and collection and management of NSF programmatic data, see the NSF-Wide investments chapter section on NSF's Evaluation and Assessment Capability.

External Evaluations Completed in FY 2014

DIR/ Office	Program, Topic, or Area Evaluated	Name of Evaluation	Contractor	Link to report
EHR	K-12 STEM Education	Monitoring Progress Toward Successful K-12 STEM Education	National Research Council, National Academies	www.nap.edu/catalog/13509/monitoring-progress-toward-successful-k-12-stem-education-a-nation
EHR	GRF	Evaluation of the Graduate Research Fellowship Program	National Opinion Research Center	www.norc.org/Research/Projects/Pages/evaluation-of-the-graduate-research-Fellowship-Program-.aspx
OIA	EPSCoR	The Experimental Program to Stimulate Competitive Research	National Academies	www.nap.edu/catalog/18384/the-experimental-program-to-stimulate-competitive-research
OIA	EPSCoR	Evaluation of the National Science Foundation's Experimental Program to Stimulate Competitive Research (EPSCoR)	Science and Technology Policy Institute	www.ida.org/~/media/Corporate/Files/Publications/STPIPubs/2015/P-5221.ashx
MPS	Mathematical Sciences Research Institutes	Pilot Case Studies for the Long Programs of the Mathematical Sciences Research Institutes	Science and Technology Policy Institute	Not available

Selected Meetings, Symposia, and Workshops in FY 2014

DIR	Workshop Name	Link to report
BIO	New Frontiers for the Integrative Study of Animal Behavior	www.nsf.gov/bio/pubs/reports/New_Frontiers_for_the_Integrative_Study_of_Animal_Behavior_workshop_report.pdf
BIO/ENG/ MPS	Design, Engineering and Selection of Novel Proteins	www.novelproteins.org/
BIO/ENG	Creating a Research Agenda for the Ecological Implications of Synthetic Biology	www.wilsoncenter.org/article/ecological-risk-research-agenda-for-synthetic-biology
CISE	Interacting with Computers All Around Us	www.cra.org/ccc/visioning/computing-visions-2025/interacting-with-the-computers-all-around-us

DIR	Workshop Name	Link to report
CISE	The New Making Renaissance: Programmable Matter and Things	www.cra.org/ccc/visioning/computing-visions-2025/new-making-renaissance
ENG	Advanced Biomanufacturing Workshop	http://grantome.com/grant/NSF/CBET-1439418
ENG	Noninvasive Imaging of Brain Function	http://people.bu.edu/bifano/NSF_NIBF_Workshop_Report_Final.pdf
OIIA	Broader Impacts Infrastructure Summit	www.nsf.gov/od/iia/publications/Broader_Impacts.pdf
MPS	Data-Driven Organic Chemistry	www.nsf.gov/awardsearch/showAward?AWD_ID=1447743
MPS	Alternative Chemistries of Life	http://chemistry.emory.edu/home/assets/alternativechem.pdf
MPS	Combinatorial Approaches to Functional Materials	www.appliedmaterials.com/company/news/events/workshop-on-combinatorial-approaches-to-functional-materials
MPS	Opportunities in Theoretical and Computational Polymeric Materials and Soft Matter	http://aztec.ms.northwestern.edu/NSFReport2013.pdf
MPS/BIO	Industrialization of Biology: A Roadmap to Accelerate Advanced Manufacturing of Chemicals	http://nas-sites.org/synbioroadmap/
SBE	International Convention on Science of Learning	http://solconvention.cite.hku.hk/
SBE	Measuring Research and Development Expenditures in the U.S. Nonprofit Sector: Conceptual and Design Issues	http://sites.nationalacademies.org/DBASSE/CNSTAT/CurrentProjects/DBASSE_087257
SBE/MPS	Quantitative Theories of Learning, Memory and Prediction	http://physicsoflivingsystems.org/workshops/learningmemoryprediction/

Data Verification and Validation

It is NSF's practice to follow Government Accountability Office (GAO) guidance and engage external contractors to conduct an independent validation and verification (V&V) review of its annual performance information, data, and processes. The guidance from GAO indicates that agencies should "…describe the means the agency will use to verify its performance data…" and "…provide confidence that [their] performance information will be credible."[1] NSF will continue this process in FY 2015 and FY 2016.

In FY 2014, IBM Global Business Services (IBM) assessed the validity of NSF data and verified the reliability of the methods used to collect, process, maintain, and report that data, and reviewed NSF's information systems based on GAO standards for application controls. IBM was able to fully or partially verify the reliability of the processes and validate the accuracy of results reported for NSF's annual performance goals.[2] IBM's FY 2014 report concluded:

> *Overall, IBM verifies that NSF relies on sound business practices, internal controls, and manual checks of system queries to ensure accurate performance reporting. NSF*

[1] GAO, The Results Act: An Evaluator's Guide to Assessing Agency Annual Performance Plans, GAO/GGD-10.1.20 (Washington, D.C.: April 1998), pp. 40-41.

[2] V&V identified data limitations for Goal 1, Public Access Priority Goal [FY 2015 goal, no FY 2014 targets], Goal 2, Data Science Priority Goal [FY 2015 goal, no FY 2014 targets]; Goal 4, Key Program Investments [data incomplete at time of publication of V&V report]; Goal 6, Enhance National Graduate Research Fellowships[NGRF program not established]; and Goal 10, Data-Driven Management Reviews [data incomplete at time of publication of V&V report]. V&V will be repeated in FY 2015 for the continuing goals (1, 2, 4, and 10).

> *maintains adequate documentation of its processes and data to allow for an effective V&V review. Based on the V&V assessment, IBM has confidence in the systems, policies, and procedures used by NSF to calculate results for its performance measures that contained targets. NSF continues to take concerted steps to improve the quality of its systems and data. IBM confirms NSF's commitment to ensuring the accuracy of its reported GPRA results, and the reliability of its processes for collecting, processing, maintaining, and reporting data for its performance goals.*[3]

Data Sources, Limitations, and Intended Use

The data and information required to measure progress towards NSF's performance goals fall into three broad categories.

- NSF automated administrative systems. Performance monitoring can be a valuable secondary function of such systems. In FY 2011, reporting included data from systems that:
  - Store and approve publications such as solicitations announcements, and Dear Colleague Letters;
  - Collect transactional data about proposal and award management;
  - Perform financial transactions;
  - Store human resources data; and
  - Permit keyword search of abstract or full texts of proposals and awards.
- The data were used either directly or for achieving milestones that involve the writing of a report. While not all goals require a high level of accuracy, data from these systems are highly reliable.
- Reports on internal activities. Milestone achievement is often determined from review of records of certain activities and events. Records of this sort tend to be compiled from review of the evidence provided by goal leaders.
- Data requests of external parties. Qualitative or quantitative information is solicited directly from awardees.

Management Challenges

A discussion of agency management challenges can be found in the FY 2014 Agency Financial Report, www.nsf.gov/pubs/2015/nsf15002/.

Burden Reduction/Unnecessary Plans and Reports to Congress

The GPRA Modernization Act of 2010 requires that agencies identify which of the plans and reports they provide to Congress are outdated or duplicative of other required plans and reports. The complete list of reports that NSF suggested for consolidation or elimination can be found on performance.gov.

Lower-Priority Program Activities

The 2016 Cuts, Consolidations, and Savings (CCS) Volume of the President's Budget identifies the lower-priority program activities under the GPRA Modernization Act (31 U.S.C. 1115(b)(10)), available at: www.whitehouse.gov/omb/budget.

Use of Non-Federal Parties

No non-federal parties were involved in preparation of this Annual Performance Report.

Classified Appendices Not Available to the Public

None

[3] IBM Global Business Services, *National Science Foundation Performance Measurement Verification and Validation Report, Fourth Quarter Fiscal Year 2014*. October 24, 2014.

TECHNICAL INFORMATION

FY 2016 Appropriations Language

National Science Foundation

RESEARCH AND RELATED ACTIVITIES

For necessary expenses in carrying out the National Science Foundation Act of 1950 (42 U.S.C. 1861 et seq.), and Public Law 86-209 (42 U.S.C. 1880 et seq.); services as authorized by section 3109 of title 5, United States Code; maintenance and operation of aircraft and purchase of flight services for research support; acquisition of aircraft; and authorized travel; $6,186,300,000, to remain available until September 30, 2017, of which not to exceed $540,000,000 shall remain available until expended for polar research and operations support, and for reimbursement to other Federal agencies for operational and science support and logistical and other related activities for the United States Antarctic program: *Provided,* That receipts for scientific support services and materials furnished by the National Research Centers and other National Science Foundation supported research facilities may be credited to this appropriation.

EDUCATION AND HUMAN RESOURCES

For necessary expenses in carrying out science, mathematics and engineering education and human resources programs and activities pursuant to the National Science Foundation Act of 1950 (42 U.S.C. 1861 et seq.), including services as authorized by section 3109 of title 5, United States Code, authorized travel, and rental of conference rooms in the District of Columbia, $962,570,000, to remain available until September 30, 2017.

MAJOR RESEARCH EQUIPMENT AND FACILITIES CONSTRUCTION

For necessary expenses for the acquisition, construction, commissioning, and upgrading of major research equipment, facilities, and other such capital assets pursuant to the National Science Foundation Act of 1950 (42 U.S.C. 1861 et seq.), including authorized travel, $200,310,000, to remain available until expended.

AGENCY OPERATIONS AND AWARD MANAGEMENT

For agency operations and award management necessary in carrying out the National Science Foundation Act of 1950 (42 U.S.C. 1861 et seq.); services authorized by section 3109 of title 5, United States Code; hire of passenger motor vehicles; uniforms or allowances therefor, as authorized by sections 5901 and 5902 of title 5, United States Code; rental of conference rooms in the District of Columbia; and reimbursement of the Department of Homeland Security for security guard services; $354,840,000: *Provided,* That not to exceed $8,280 is for official reception and representation expenses: *Provided further,* That contracts may be entered into under this heading in fiscal year 2016 for maintenance and operation of facilities and for other services to be provided during the next fiscal year; *Provided further*, That of the amount provided for costs associated with the acquisition, occupancy, and related costs of new headquarters space, not more than $28,400,000 shall remain available until expended. *Provided further*, That $2,852,000 will be used to support the agency's activities related to implementation of the Digital Accountability and Transparency Act (DATA Act; Public Law 113–101; 31 U.S.C. 6101 note) to include changes in business processes, workforce, or information technology to support high quality, transparent Federal spending information, of which $852,000 shall be available to support the agency's implementation of a uniform procurement instrument identifier as described in 48 C.F.R. subpart 4.16.

OFFICE OF INSPECTOR GENERAL

For necessary expenses of the Office of Inspector General as authorized by the Inspector General Act of 1978, $15,160,000, of which $400,000 shall remain available until September 30, 2017.

OFFICE OF THE NATIONAL SCIENCE BOARD

For necessary expenses (including payment of salaries, authorized travel, hire of passenger motor vehicles, the rental of conference rooms in the District of Columbia, and the employment of experts and consultants under section 3109 of title 5, United States Code) involved in carrying out section 4 of the National Science Foundation Act of 1950 (42 U.S.C 1863) and Public Law 86-209 (42 U.S.C. 1880 et seq.), $4,370,000: *Provided*, That not to exceed $2,500 shall be available for official reception and representation expenses.

ADMINISTRATIVE PROVISION

Not to exceed 5 percent of any appropriation made available for the current fiscal year for the National Science Foundation in this Act may be transferred between such appropriations, but no such appropriation shall be increased by more than 10 percent by any such transfers. Any transfer pursuant to this section shall be treated as a reprogramming of funds under section 505 of this Act and shall not be available for obligation except in compliance with the procedures set forth in that section.

SUMMARY OF FY 2016 BUDGETARY RESOURCES BY ACCOUNT

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	FY 2016 Request Change Over FY 2015 Estimate Amount	Percent
RESEARCH AND RELATED ACTIVITIES					
Appropriation	$5,808.92	$5,933.65	$6,186.30	$252.65	4.3%
Unobligated Balance Available Start of Year	10.16	57.66		-57.66	
Unobligated Balance Available End of Year	-57.66				
Adjustments to Prior Year Accounts[1]	21.18				
Subtotal, R&RA	5,782.60	5,991.31	6,186.30	194.99	3.3%
Transferred to/from other funds	-7.28	-	-	-	
Total Budgetary Resources	$5,775.32	$5,991.31	$6,186.30	$194.99	3.3%
EDUCATION AND HUMAN RESOURCES					
Appropriation	$846.50	$866.00	$962.57	$96.57	11.2%
Unobligated Balance Available Start of Year	2.18	16.37		-16.37	
Unobligated Balance Available End of Year	-16.37				
Adjustments to Prior Year Accounts[1]	0.77				
Subtotal, EHR	833.08	882.37	962.57	80.20	9.1%
Transferred to/from other funds	-1.06	-	-	-	
Total Budgetary Resources	$832.02	$882.37	$962.57	$80.20	9.1%
MAJOR RESEARCH EQUIPMENT & FACILITIES CONSTRUCTION					
Appropriation	$200.00	$200.76	$200.31	-$0.45	-0.2%
Unobligated Balance Available Start of Year	0.38	0.39		-0.39	
Unobligated Balance Available End of Year	-0.39				
Adjustments to Prior Year Accounts[1]	0.01				
Subtotal, MREFC	200.00	201.15	200.31	-0.84	-0.4%
Transferred to/from other funds	-	-	-	-	
Total Budgetary Resources	$200.00	$201.15	$200.31	-$0.84	-0.4%
AGENCY OPERATIONS AND AWARD MANAGEMENT					
Appropriation	$298.00	$325.00	$354.84	$29.84	9.2%
Unobligated Balance - Expired	-0.31				
Subtotal, AOAM	297.69	325.00	354.84	29.84	9.2%
Transferred to/from other funds	8.26	-	-	-	
Total Budgetary Resources	$305.95	$325.00	$354.84	$29.84	9.2%

Totals may not add due to rounding.

[1]Adjustments include upward and downward adjustments to prior year obligations.

SUMMARY OF FY 2016 BUDGETARY RESOURCES BY ACCOUNT

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	FY 2016 Request Change Over FY 2015 Estimate Amount	Percent
NATIONAL SCIENCE BOARD					
Appropriation	$4.30	$4.37	$4.37	-	-
Unobligated Balance - Expired	-0.05				
Total Budgetary Resources	$4.25	$4.37	$4.37	-	-
OFFICE OF INSPECTOR GENERAL					
Appropriation	$14.20	$14.43	$15.16	$0.73	5.1%
Unobligated Balance Available Start of Year	-	0.40		-0.40	
Unobligated Balance Available End of Year	-0.40				
Adjustments to Prior Year Accounts[1]	-0.04				
Subtotal, OIG	13.76	14.83	15.16	0.33	2.2%
Transferred to/from other funds	0.08	-	-	-	
Total Budgetary Resources	$13.84	$14.83	$15.16	$0.33	2.2%
TOTAL DISCRETIONARY, NATIONAL SCIENCE FOUNDATION	$7,131.39	$7,419.03	$7,723.55	$304.52	4.1%
EDUCATION AND HUMAN RESOURCES, H-1B					
Appropriation, Mandatory (H1-B Non-Immigrant Petitioner Fees)	$132.49	$100.00	$100.00	-	-
Unobligated Balance Available Start of Year	104.45	108.35		-108.35	
Sequestration Previously Unavailable	5.10	9.54		-9.54	
Unobligated Balance Available End of Year	-108.35				
Adjustments to Prior Year Accounts[1]	5.26				
Sequestration Pursuant OMB M-13-06	-9.54				
Total Budgetary Resources	$129.41	$217.89	$100.00	-$117.89	-54.1%
DONATIONS					
Mandatory Programs (Special or Trust Fund)	$32.52	$45.00	$45.00	-	-
Unobligated Balance Available Start of Year	32.87	27.85		-27.85	
Unobligated Balance Available End of Year	-27.85				
Adjustments to Prior Year Accounts[1]	0.28				
Total Budgetary Resources	$37.82	$72.85	$45.00	-$27.85	-38.2%
TOTAL, NATIONAL SCIENCE FOUNDATION	$7,298.62	$7,709.77	$7,868.55	$158.78	2.1%

Totals may not add due to rounding.

[1]Adjustments include upward and downward adjustments to prior year obligations.

NSF FY 2016 Request Funding by Program

(Dollars in Millions)

PROGRAM	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	FY 2016 Request Change Over FY 2015 Estimate Amount	FY 2016 Request Change Over FY 2015 Estimate Percent
BIOLOGICAL SCIENCES (BIO)					
BIOLOGICAL INFRASTRUCTURE	$131.81	$142.60	$145.41	$2.81	2.0%
EMERGING FRONTIERS	105.79	97.06	106.14	9.08	9.4%
ENVIRONMENTAL BIOLOGY	138.70	143.49	144.76	1.27	0.9%
INTEGRATIVE ORGANISMAL SYSTEMS	215.21	213.71	215.40	1.69	0.8%
MOLECULAR & CELLULAR BIOSCIENCES	129.32	134.16	136.21	2.05	1.5%
TOTAL, BIO	**$720.84**	**$731.03**	**$747.92**	**$16.89**	**2.3%**
COMPUTER & INFORMATION SCIENCE & ENGINEERING (CISE)					
ADVANCED CYBERINFRASTRUCTURE	$211.93	$218.80	$227.29	$8.49	3.9%
COMPUTING & COMMUNICATION FOUNDATIONS	184.88	191.33	198.59	7.26	3.8%
COMPUTER & NETWORK SYSTEMS	220.02	227.66	236.32	8.66	3.8%
INFORMATION & INTELLIGENT SYSTEMS	184.87	191.65	198.94	7.29	3.8%
INFORMATION TECHNOLOGY RESEARCH	90.91	92.29	93.27	0.98	1.1%
TOTAL, CISE	**$892.60**	**$921.73**	**$954.41**	**$32.68**	**3.5%**
ENGINEERING (ENG)					
CHEMICAL, BIOENGINEERING, ENVIRONMENTAL, & TRANSPORT SYSTEMS	$167.76	$177.82	$192.26	$14.44	8.1%
CIVIL, MECHANICAL, & MANUFACTURING INNOVATION	195.23	209.52	222.73	13.21	6.3%
ELECTRICAL, COMMUNICATIONS, & CYBER SYSTEMS	100.37	110.43	119.24	8.81	8.0%
INDUSTRIAL INNOVATION & PARTNERSHIPS	205.99	226.98	248.11	21.13	9.3%
[SBIR/STTR]	*[159.99]*	*[177.11]*	*[194.36]*	*[17.25]*	*[9.7%]*
ENGINEERING EDUCATION & CENTERS	119.50	117.49	110.39	-7.10	-6.0%
EMERGING FRONTIERS AND MULTIDISCIPLINARY ACTIVITIES[1]	44.27	50.07	56.49	6.42	12.8%
TOTAL, ENG	**$833.12**	**$892.31**	**$949.22**	**$56.91**	**6.4%**
GEOSCIENCES (GEO)					
ATMOSPHERIC & GEOSPACE SCIENCES	$250.85	$251.15	$262.88	$11.73	4.7%
EARTH SCIENCES	177.81	177.20	188.21	11.01	6.2%
INTEGRATIVE & COLLABORATIVE EDUCATION AND RESEARCH	83.53	83.74	95.20	11.46	13.7%
OCEAN SCIENCES	356.27	355.95	369.61	13.66	3.8%
POLAR PROGRAMS	452.87	436.35	449.51	13.16	3.0%
[US Antarctic Logistical Support Activities]	*[68.94]*	*[67.52]*	*[67.52]*	*[-]*	*[-]*
TOTAL, GEO	**$1,321.32**	**$1,304.39**	**$1,365.41**	**$61.02**	**4.7%**
MATHEMATICAL & PHYSICAL SCIENCES (MPS)					
ASTRONOMICAL SCIENCES	$238.36	$244.16	$246.55	$2.39	1.0%
CHEMISTRY	235.18	243.85	251.20	7.35	3.0%
MATERIALS RESEARCH	267.09	306.99	315.80	8.81	2.9%
MATHEMATICAL SCIENCES	224.97	231.73	235.47	3.74	1.6%
PHYSICS	267.09	274.99	277.37	2.38	0.9%
MULTIDISCIPLINARY ACTIVITIES	35.17	35.00	39.84	4.84	13.8%
TOTAL, MPS	**$1,267.86**	**$1,336.72**	**$1,366.23**	**$29.51**	**2.2%**

Totals may not add due to rounding.

[1] The Office of Emerging Frontiers and Multidisciplinary Activities (EFMA) is the reorganized form of Emerging Frontiers in Research and Innovation (EFRI), beginning in FY 2015. FY 2014 Actual obligations for all divisions have been restated for comparability.

(Dollars in Millions)

PROGRAM	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	FY 2016 Request Change Over FY 2015 Estimate Amount	Percent
SOCIAL, BEHAVIORAL & ECONOMIC SCIENCES (SBE)					
BEHAVIORAL AND COGNITIVE SCIENCES	$93.10	$94.47	$101.79	$7.32	7.7%
SOCIAL AND ECONOMIC SCIENCES	95.87	97.72	105.13	7.41	7.6%
MULTIDISCIPLINARY ACTIVITIES	28.14	29.25	30.23	0.98	3.4%
NATIONAL CENTER FOR SCIENCE & ENGINEERING STATISTICS	39.73	50.76	54.31	3.55	7.0%
TOTAL, SBE	**$256.84**	**$272.20**	**$291.46**	**$19.26**	**7.1%**
OFFICE OF INTERNATIONAL SCIENCE AND ENGINEERING (OISE)[2]	**$48.31**	**$48.52**	**$51.02**	**$2.50**	**5.2%**
INTEGRATIVE ACTIVITIES (IA)[2]					
EXPERIMENTAL PROGRAM TO STIMULATE COMPETITIVE RESEARCH (EPSCOR)	$158.19	$159.69	$169.99	$10.30	6.4%
INTEGRATIVE ACTIVITIES	274.93	265.65	289.16	23.51	8.8%
[Major Research Instrumentation (MRI)]	*[89.59]*	*[75.00]*	*[75.00]*	*[-]*	*[-]*
TOTAL, IIA	**$433.12**	**$425.34**	**$459.15**	**$33.81**	**7.9%**
UNITED STATES ARCTIC RESEARCH COMMISSION	**$1.30**	**$1.41**	**$1.48**	**$0.07**	**5.0%**
TOTAL, RESEARCH AND RELATED ACTIVITIES	**$5,775.32**	**$5,933.65**	**$6,186.30**	**$252.66**	**4.3%**
EDUCATION & HUMAN RESOURCES (EHR)					
GRADUATE EDUCATION	$245.58	$273.41	$295.64	$22.23	8.1%
HUMAN RESOURCE DEVELOPMENT	139.21	143.73	145.59	1.86	1.3%
RESEARCH ON LEARNING IN FORMAL AND INFORMAL SETTINGS	230.13	221.52	253.08	31.56	14.2%
UNDERGRADUATE EDUCATION	217.10	227.34	268.26	40.92	18.0%
TOTAL, EDUCATION & HUMAN RESOURCES	**$832.02**	**$866.00**	**$962.57**	**$96.57**	**11.2%**
MAJOR RESEARCH EQUIPMENT & FACILITIES CONSTRUCTION	**$200.00**	**$200.76**	**$200.31**	**-$0.45**	**-0.2%**
AGENCY OPERATIONS AND AWARD MANAGEMENT	**$305.95**	**$325.00**	**$354.84**	**$29.84**	**9.2%**
OFFICE OF THE INSPECTOR GENERAL	**$13.84**	**$14.43**	**$15.16**	**$0.73**	**5.1%**
NATIONAL SCIENCE BOARD	**$4.25**	**$4.37**	**$4.37**	**-**	**-**
TOTAL, NATIONAL SCIENCE FOUNDATION	**$7,131.39**	**$7,344.21**	**$7,723.55**	**$379.34**	**5.2%**

Totals may not add due to rounding.

[1] The Office of Emerging Frontiers and Multidisciplinary Activities (EFMA) is the reorganized form of Emerging Frontiers in Research and Innovation (EFRI), beginning in FY 2015. FY 2014 Actual obligations for all divisions have been restated for comparability.

[2] This table reflects the realignment, expected in FY 2015, of the Office of International Science and Engineering and Integrative Activities as separate budget activities. All years are shown in the FY 2015 structure for comparability.

OBJECT CLASSIFICATION
NSF Consolidated Obligations

(Dollars in Millions)

Object Class Code	Standard Title	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
11.1	Full-time permanent	$157	$165	$207
11.3	Other than full-time permanent	11	11	11
11.5	Other personnel compensation	2	2	2
11.8	Special personal service payment	-	-	-
	Total personnel compensation	170	178	220
12.1	Civilian personnel benefits	48	50	48
21.0	Travel and transportation of persons	21	21	21
23.1	Rental payments	30	34	30
23.3	Communications, utilities, and miscellaneous charges	3	3	3
24.0	Printing and Reproduction	-	-	-
25.1	Advisory and assistance services	169	169	169
25.2	Other services	28	28	28
25.3	Purchases of goods and services from Government Accounts	37	37	37
25.4	Operation and maintenance of facilities	361	388	364
25.5	Research and development contracts	6	7	7
26.0	Operation and maintenance of equipment	-	4	4
26.0	Supplies and materials	4	4	4
31.0	Equipment	4	9	4
41.0	Grants, subsidies, and contributions	6,417	6,748	6,929
	Total, Direct obligations[1]	$7,298	$7,680	$7,868

Totals may not add due to rounding.

[1] Includes mandatory obligations, but excludes obligations for reimbursable accounts.

NSF REIMBURSABLE ACTIVITY

Reimbursements for the Research and Related Activities Appropriation and the Education and Human Resources Appropriation are realized from other federal agencies that have entered into interagency agreements with the Foundation. NSF enters into agreements (including Memoranda of Understanding) with other U.S. government agencies, as authorized by the NSF Act, 42 U.S.C. 1870 (c) and the Economy Act: 31 U.S.C. 1535, under which NSF assumes some responsibility for activities supported by these agencies. These activities can include jointly funded projects and programs, support of research operations and logistics, and access to NSF supported research facilities.

Reimbursements by Agency

(Dollars in Millions)

DEPARTMENT/AGENCY	FY 2014 Actual
DEFENSE	
Air Force	$13.4
Army	$6.9
Other DoD (DARPA, NSA & Intelligence)	$7.4
Subtotal, DoD	$27.7
Agriculture	$1.5
Commerce (Including Census, NOAA, & NIST)	$11.0
Energy	$10.0
Health & Human Services	$22.8
Interior	$0.7
Justice	$1.0
Homeland Security	$1.4
NASA	$5.6
State	$2.4
Transportation	$5.0
OTHER (less than $500,000)	$2.7
TOTAL REIMBURSEMENTS	**$91.8**

Totals may not add due to rounding

Consistent with applicable legislation and GAO decisions, agreements include reimbursement for costs that are incurred in the management and administration of these awards.

In FY 2014, the largest portion of NSF's reimbursable activity came from joint activities with the Department of Defense (30.2 percent), the Department of Health and Human Services (24.8 percent), the Department of Commerce (including the Census Bureau, and the National Oceanic and Atmospheric Administration, and the National Institute of Standards and Technology) (12.0 percent), the Department of Energy (10.9 percent), the National Aeronautics and Space Administration (6.1 percent), and the Department of Transportation (5.6 percent). Reimbursable activities with the Department of Defense were largely for the management of the National Center for Atmospheric Research. Reimbursable activities with the Department of Health and Human Services are for non-medical biological research such as the Human Frontiers Science Program.

NSF Personnel Summary of Permanent Appointments

Statutory Pay Systems	FY 2014 Actual Appointments
ES	63
AD	339
GS/GM-15	85
GS/GM-14	167
GS/GM-13	136
GS-12	114
GS-11	92
GS-10	4
GS-9	64
GS-8	18
GS-7	49
GS-6	8
GS-5	1
GS-4	-
Subtotal, GS/GM	738
Total, Permanent Appointments	1,140
Average Salary	$120,738

All data are for permanent appointments.

EXPLANATION OF FY 2014 CARRYOVER INTO FY 2015 BY ACCOUNT

The National Science Foundation's (NSF) total unobligated balance of $211.02 million ($68.94 million for Discretionary accounts, including $5.88 million for Incoming Interagency Reimbursable Agreements, and $136.20 million for Mandatory accounts) is described below.

DISCRETIONARY

Within the **Research and Related Activities (R&RA)** account, $57.66 million (including $5.60 million in reimbursable funds) was carried over into FY 2015. Obligation of all of these funds is expected by the end of the second quarter of FY 2015, unless noted otherwise.

- Directorate for Engineering (ENG) carried over $18.07 million.
  - $8.47 million is for the solicitation NSF14-557, Decision Frameworks for Multi-Hazard Resilient and Sustainable Buildings (RSB), which had a proposal deadline date of July 24, 2014. Programs involved include Network for Earthquake Engineering Simulation (NEES) Operations and Research, Hazard Mitigation and Structural Engineering, Geotechnical Engineering, Engineering and Systems Design, and Systems Science. This solicitation replaces the annual NEES Research solicitation as the program undergoes the transition from NEES to the follow-on facility.
  - $3.09 million is for Sustainability Research Networks (SRN) connected to the SRN solicitation (14-534), which was released later than anticipated. This competition covers both FY 2014 and FY 2015.
  - $6.51 million is for awards related to the Brain Research through Advancing Innovative Neurotechnologies (BRAIN) Initiative, Early Concept Grant for Exploratory Research (EAGER), joint partnership with the Air Force Office of Scientific Research (AFOSR), and Dear Colleague Letters (DCLs) for other items that were unable to be processed before the end of the fiscal year.

- Directorate for Mathematical and Physical Sciences (MPS) carried over $29.81 million.
  - MPS carried over $29.81 million for the Materials Research Science and Engineering Centers (MRSEC) awards in the Division of Materials Research. Awards were not ready for obligation before the close of FY 2014.

- Integrative Activities (IA) carried over $1.67 million.
  - $1.67 million is for Evaluation and Assessment Capability (EAC). This amount includes funding for the Graduate Research Postdoctoral Fellowship program pilot longitudinal monitoring/data collection, information system to store evaluation reports and statements of work, development of internal EAC website, NSF Innovation Corps (I-Corps™) longitudinal data collection for I-Corps™ Teams (evaluation and initial data collection system), portfolio analysis pilots, and the G8 meeting.

- The carryover associated with R&RA includes $100,018 for the operations of the National Coordination Office/Networking and Information Technology Research and Development, and $20,354 for the operations of the National Nanotechnology Coordination Office.

- Within R&RA, $5.60 million of incoming two-year interagency funds were carried over.

- The remaining R&RA carryover of $2.39 million consists of funds from throughout the Foundation for projects that were not ready for obligation in FY 2014.

Within the **Education and Human Resources (EHR)** account, $16.37 million (including $281,000 in reimbursable funds) was carried over into FY 2015. It is estimated that these funds will be obligated during the second quarter of FY 2015.

- $12.50 million for the NSF Research Traineeships (NRT) was carried over. The solicitation for the cross-directorate program was released on March 24, 2014, with 258 proposals received by the June 24, 2014 due date. Thirteen panels were scheduled during the August 18 to September 15 timeframe. Award recommendations will be finalized during the second quarter of FY 2015.

- $2.75 million for the Excellence Awards in Science and Engineering (EASE) Program:
  - $2.36 million for the Presidential Awards for Excellence in Mathematics and Science Teaching (PAEMST) program was carried over into FY 2015. The FY 2013 awardees were not recognized in FY 2014 and have been scheduled to be recognized in FY 2015 along with the FY 2014 awardees.
  - $394,000 for the Presidential Awards for Excellence in Science, Mathematics and Engineering Mentoring (PAESMEM) was carried over into FY 2015. The FY 2012 and FY 2013 awardees were not recognized in FY 2014. They are scheduled to be recognized in FY 2015 along with FY 2014 awardees.

- $827,693 for the Robert Noyce program was carried over into FY 2015 for awards that were not ready for obligation.

- Within EHR, $281,000 of incoming two-year interagency funds were carried over.

Within the **Major Research Equipment and Facilities Construction** account an amount of $390,592 was carried over into FY 2015.

Within the **Office of Inspector General (OIG)** account, $400,000 in two-year funds was carried over into FY 2015. Most of these funds are expected to be used to procure audit and forensic contracts during the second quarter of FY 2015. The selection of awards and institutions to be audited will require careful preparation and is subject to changing circumstances and new information that may require additional time to process.

MANDATORY

Within the **H-1B Nonimmigrant Petitioner** account, $108.35 million was carried over and consists of $27.09 million for Innovative Technology Experiences for Students and Teachers (ITEST) and $81.26 million for Scholarship in Science, Technology, Engineering, and Mathematics (S-STEM). Since NSF receives the largest payments of H-1B visa fees in August and September, there was insufficient time to obligate the receipts on awards before the end of the fiscal year. These resources will allow both ITEST and S-STEM to support awards through the second quarter of FY 2015.

Within the **Donations** account, $27.85 million was carried over into FY 2015. Donations were received from foreign governments, organizations, and individuals to fund various cooperative efforts in science, research, and education.

Discretionary and Mandatory Accounts
Distribution of FY 2014 Carryover into FY 2015
(Dollars in Millions)

Discretionary Accounts	**Amount**
Research and Related Activities	$57.66
Education and Human Resources	16.37
Major Research Equipment and Facilities Construction	0.39
Office of Inspector General	0.40
Subtotal	**74.82**
Mandatory Accounts	
H-1B Non-Immigrant Petitioner	108.35
Donations (Special or Trust Fund)	27.85
Subtotal	**136.20**
TOTAL	**$211.02**

Totals may not add due to rounding.

QUANTITATIVE DATA TABLE

NATIONAL SCIENCE FOUNDATION

Research and Development Special Analysis

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
Investment Activities			
Conduct of Research and Development			
Basic Research	$4,725.21	$4,834.16	$5,061.68
Applied Research	678.10	727.60	801.86
Subtotal, Conduct of R&D	5,403.31	5,561.76	5,863.54
Physical Assets			
Research and Development Facilities	206.97	211.57	208.31
Research and Development Major Equipment	189.91	225.24	236.77
Subtotal, Physical Assets	396.88	436.81	445.08
Total, Research and Development	5,800.19	5,998.57	6,308.62
Conduct of Education and Training	741.26	744.97	763.48
Non-Investment Activities	589.94	600.67	651.45
TOTAL	$7,131.39	$7,344.21	$7,723.55

Totals may not add due to rounding.

QUANTITATIVE DATA TABLE

RESEARCH AND RELATED ACTIVITIES

Research and Development Special Analysis

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
Investment Activities			
Conduct of Research and Development			
Basic Research	$4,609.37	$4,716.27	$4,904.74
Applied Research	464.39	458.67	490.63
Subtotal, Conduct of R&D	5,073.76	5,174.94	5,395.37
Physical Assets			
Research and Development Facilities	6.97	10.81	8.00
Research and Development Major Equipment	188.59	224.24	235.77
Subtotal, Physical Assets	195.56	235.05	243.77
Total, Research and Development	5,269.32	5,409.99	5,639.14
Conduct of Education and Training	275.11	299.91	307.95
Non-Investment Activities	230.90	223.75	239.21
TOTAL	$5,775.32	$5,933.65	$6,186.30

Totals may not add due to rounding.

QUANTITATIVE DATA TABLE

EDUCATION AND HUMAN RESOURCES

Research and Development Special Analysis

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
Investment Activities			
Conduct of Research and Development			
Basic Research	$115.84	$117.89	$156.94
Applied Research	213.71	268.93	311.23
Subtotal, Conduct of R&D	329.55	386.82	468.17
Physical Assets			
Research and Development Facilities	-	-	-
Research and Development Major Equipment	1.32	1.00	1.00
Subtotal, Physical Assets	1.32	1.00	1.00
Total, Research and Development	330.87	387.82	469.17
Conduct of Education and Training	466.15	445.06	455.53
Non-Investment Activities	35.00	33.12	37.87
TOTAL	$832.02	$866.00	$962.57

Totals may not add due to rounding.

QUANTITATIVE DATA TABLE

MAJOR RESEARCH EQUIPMENT AND FACILITIES CONSTRUCTION

Research and Development Special Analysis

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
Investment Activities			
Conduct of Research and Development			
Basic Research	-	-	-
Applied Research	-	-	-
Subtotal, Conduct of R&D	-	-	-
Physical Assets			
Research and Development Facilities	$200.00	$200.76	$200.31
Research and Development Major Equipment	-	-	-
Subtotal, Physical Assets	200.00	200.76	200.31
Total, Research and Development	200.00	200.76	200.31
Conduct of Education and Training	-	-	-
Non-Investment Activities	-	-	-
TOTAL	$200.00	$200.76	$200.31

Totals may not add due to rounding.

QUANTITATIVE DATA TABLE

AGENCY OPERATIONS AND AWARD MANAGEMENT

Research and Development Special Analysis

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
Investment Activities			
Conduct of Research and Development			
Basic Research	-	-	-
Applied Research	-	-	-
Subtotal, Conduct of R&D	-	-	-
Physical Assets			
Research and Development Facilities	-	-	-
Research and Development Major Equipment	-	-	-
Subtotal, Physical Assets	-	-	-
Total, Research and Development	-	-	-
Conduct of Education and Training	-	-	-
Non-Investment Activities	$305.95	$325.00	$354.84
TOTAL	$305.95	$325.00	$354.84

Totals may not add due to rounding.

QUANTITATIVE DATA TABLE

OFFICE OF INSPECTOR GENERAL

Research and Development Special Analysis

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
Investment Activities			
Conduct of Research and Development			
Basic Research	-	-	-
Applied Research	-	-	-
Subtotal, Conduct of R&D	-	-	-
Physical Assets			
Research and Development Facilities	-	-	-
Research and Development Major Equipment	-	-	-
Subtotal, Physical Assets	-	-	-
Total, Research and Development	-	-	-
Conduct of Education and Training	-	-	-
Non-Investment Activities	$13.84	$14.43	$15.16
TOTAL	$13.84	$14.43	$15.16

Totals may not add due to rounding.

QUANTITATIVE DATA TABLE

NATIONAL SCIENCE BOARD

Research and Development Special Analysis

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
Investment Activities			
Conduct of Research and Development			
Basic Research	-	-	-
Applied Research	-	-	-
Subtotal, Conduct of R&D	-	-	-
Physical Assets			
Research and Development Facilities	-	-	-
Research and Development Major Equipment	-	-	-
Subtotal, Physical Assets	-	-	-
Total, Research and Development	-	-	-
Conduct of Education and Training	-	-	-
Non-Investment Activities	$4.25	$4.37	$4.37
TOTAL	$4.25	$4.37	$4.37

Totals may not add due to rounding.