NATIONAL SCIENCE FOUNDATION

FY 2019 Budget Request to Congress

February 28, 2018

NOTES

Numbers in the tables and figures may not add up to totals because of rounding.

Amounts below the appropriations account level for the FY 2018 Annualized Continuing Resolution were not available at the time this budget was published.

Common Acronyms Used in Budget Request to Congress

Appropriation Accounts

- AOAM: Agency Operations and Award Management
- EHR: Education and Human Resources
- MREFC: Major Research Equipment and Facilities Construction
- NSB: National Science Board
- OIG: Office of Inspector General
- R&RA: Research and Related Activities

Directorates and offices

- BIO: Directorate for Biological Sciences
- CISE: Directorate for Computer and Information Science and Engineering
- ENG: Directorate for Engineering
- EHR: Directorate for Education and Human Resources
- GEO: Directorate for Geosciences
- MPS: Directorate for Mathematical and Physical Sciences
- SBE: Directorate for Social, Behavioral, and Economic Sciences
- OISE: Office of International Science and Engineering
- OPP: Office of Polar Programs
- OIA: Office of Integrative Activities [organizational unit]
- IA: Integrative Activities [budget activity]

NSF-Wide Investments

- GRFP: Graduate Research Fellowship Program
- INFEWS: Innovations at the Nexus of Food, Energy, and Water Systems
- IUSE: Improving Undergraduate STEM Education
- I-Corps™: NSF Innovation Corps
- NRT: NSF Research Traineeship
- NSF INCLUDES: Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science
- SaTC: Secure and Trustworthy Cyberspace
- UtB: Understanding the Brain

National Science and Technology Council Crosscuts:

- NITRD: Networking and Information Technology Research and Development
- NNI: National Nanotechnology Initiative
- USGCRP: U.S. Global Change Research Program

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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 FY 2019 Budget Request for the National Science Foundation reflects the Administration's commitment to NSF's role in strengthening the Nation's economy, national security, and global leadership, while also restraining non-defense spending across the government. NSF funds the basic research that advances cybersecurity, infrastructure, manufacturing, and military technology, and sustains American preeminence in innovation. NSF also makes critical investments in science, technology, engineering, and mathematics (STEM) education that prepare the Nation's future-focused workforce. NSF investments have led to research that has yielded 231 Nobel prizes. Notable among these many outstanding investments is the Laser Interferometer Gravitational Wave Observatory, where gravitational waves have been detected following black hole mergers and most recently, a merger of two neutron-stars.

NSF is the only federal agency dedicated to funding basic non-biomedical research across all areas of science and engineering. NSF is also committed to the development of a future-focused science and engineering workforce that draws on the talents of all Americans. The reach of the agency's investments is broad. It is these investments that have helped sustain the U.S. role as a global leader in innovation since 1950. NSF investments drive economic growth, increase prosperity, and create jobs for the Nation and all Americans. Investments in basic and early-stage research create a foundation for breakthroughs that advance national security and preserve global leadership. The complex global and domestic challenges facing the Nation today will require NSF investments. NSF continues to increase agency efficiency and effectiveness, by improving the stewardship of multi-user facilities, seeding innovative, forward thinking convergent ideas to propel human knowledge forward into new realms, and developing additional and stronger public-private partnerships.

Scientific infrastructure has long been a cornerstone of NSF-funded research across the Nation. In FY 2019, NSF will make a strong commitment to agency supported research infrastructure. NSF will invest in the Antarctic Infrastructure Modernization for Science project, a necessity for maintaining U.S. scientific and geopolitical eminence across the continent of Antarctica. The agency will begin support for Mid-scale Research Infrastructure, an effort that will address a gap between existing research instrumentation and existing large facility funding; making more science possible while engaging more people in the pursuit of knowledge. Using funds in the Major Research Equipment and Facilities Construction account, NSF will fund the construction of two Regional Class Research Vessels, pivotal components in the modernization of the academic research fleet that helps scientists to understand numerous coastal processes.

Complementing NSF's commitment to infrastructure is the agency's constant pursuit of innovation. In FY 2019, NSF will invest in its 10 Big Ideas, research agendas that identify areas at the frontiers of science and engineering which promise to be among the most transformative in the coming decades. NSF will also initiate two Convergence Accelerators, which are new organizational structures that will leverage resources across the agency to support the most innovative science. NSF's support for the Big Ideas and the Convergence Accelerators reflects the agency's ongoing commitment to being on the cutting-edge, while supporting the fundamental research in all areas of science that has advanced the Nation since the agency's founding. Collaboration and convergence are required across NSF in order to achieve the agency's mission

and support the maximum number of researchers. No longer is any one research directorate at NSF the sole NSF funder of science in a given field. Science and engineering today requires innovative approaches to leveraging resources across all fields of science.

Federal investment in basic research and the STEM workforce, led by NSF, is vital to the Nation's continued global leadership. Other nations continue to increase their support of research, development, and STEM education, as they innovate in next-generation technologies. China and the European Union have invested significantly in quantum technology, and continue to invest billions of dollars in artificial intelligence research with an eye to a future of global leadership in these areas. There is unprecedented global competition for highly skilled, technical workers who will lead tomorrow's innovations. Continued U.S. support for basic research has never been more vital for the Nation and for the world.

NSF is essential to advancing American leadership in science and technology. NSF investments in all 50 states of the Union and all U.S. territories have resulted in both short- and long- term innovation and the robust creation of jobs. Over 50 percent of America's economic growth of the past 50 years is attributable to technological innovation. This innovation depends on significant investment in basic research. NSF had a role in the development of the Internet, 3-D printing, cell phones, and in responding to national and international crises, including the Ebola and Zika outbreaks, the Deepwater Horizon oil spill, Hurricane Katrina, and more recently, Hurricanes Harvey, Irma, and Maria.

NSF awarded $5.30 million in 59 grants after recent natural disasters to quickly mobilize resources to aid in relief efforts, to helping understand how to better protect human lives, infrastructure, and resources during these crises. These awards helped scientists understand how to best respond to disasters in the future and how to provide immediate assistance when people needed it most. NSF investments in disaster research have advanced understanding of the paths of tropical cyclones, improved water decontamination, deployed underwater rescue robots, and helped to understand the long-term psychological and emotional effects of disasters. After hurricanes Harvey and Irma hit, researchers quickly used the NSF-funded Stampede2 supercomputer to create useful computer models that showed the likely depth and location of water in different regions, which helped first responders navigate flooded areas and allowed them to reach those most in need of assistance. Other researchers are studying the short- and long-term effects of extreme flooding in urban areas to understand the spread of diseases after floods.

Finally, NSF remains committed to investing in the basic research that helps the U.S. military both on and off the battlefield. This includes innovative military technologies to support those on the front lines. Years of NSF-funded research helped create the Worldwide-Integrated Crisis Early Warning System, which has helped the military predict where conflict is likely to break out, and how to best mitigate a potential crisis. NSF funding developed Hemogrip, a biopolymer foam that expands in a wound to minimize blood loss and save lives on the battlefield. NSF investments also work to improve the lives of veterans as they readjust to civilian life. NSF-funded research has created better prosthetics and improved screening and treatment of post-traumatic stress disorder, depression, and other issues afflicting America's veterans.

NSF's FY 2019 Budget Request is $7.47 billion, level to FY 2017 Enacted.

NSF's 10 Big Ideas

In 2019, NSF will support 10 Big Ideas, which are bold ideas that identify areas for future, long-term investment at the frontiers of science and engineering. With its broad portfolio of investments, NSF is uniquely suited to advance this set of cutting-edge research agendas and processes that will require collaborations with industry, private foundations, other agencies, science academies and societies, and universities and other education institutions. The Big Ideas represent unique opportunities to position our Nation at the frontiers—indeed to define the frontiers—of global science and engineering leadership and to invest in fundamental research that advances America's economic competitiveness and security.

About the Big Ideas

Six of the Big Ideas focus on research, building on a foundation made possible by earlier investments in fundamental research. Four of the Big Ideas focus on process, and address NSF practices that could be altered or enhanced to capture the best research and to welcome new members to the Nation's science and engineering community.

Research Big Ideas:

1. **Harnessing the Data Revolution for 21st-Century Science and Engineering (HDR)**—Engaging NSF's research community in the pursuit of fundamental research in data science and engineering, the development of a cohesive, federated, national-scale approach to research data infrastructure, and the development of a 21st-century data-capable workforce.

2. **The Future of Work at the Human Technology Frontier (FW-HTF)**—Catalyzing interdisciplinary science and engineering research to understand and build the human-technology relationship; design new technologies to augment human performance; illuminate the emerging socio-technological landscape; and foster lifelong and pervasive learning with technology.

3. **Windows on the Universe (WoU): The Era of Multi-messenger Astrophysics**—Using powerful new syntheses of observational approaches to provide unique insights into the nature and behavior of matter and energy and to answer some of the most profound questions before humankind.

4. **The Quantum Leap (QL): Leading the Next Quantum Revolution**—Exploiting quantum mechanics to observe, manipulate, and control the behavior of particles and energy at atomic and subatomic scales; and developing next-generation quantum-enabled science and technology for sensing, information processing, communicating, and computing.

5. **Understanding the Rules of Life (URoL): Predicting Phenotype**—Elucidating the sets of rules that predict an organism's observable characteristics, i.e., its phenotype.

6. **Navigating the New Arctic (NNA)**—Establishing an observing network of mobile and fixed platforms and tools across the Arctic to document and understand the Arctic's rapid biological, physical, chemical, and social changes.

Process Big Ideas:

7. **NSF INCLUDES—**Transforming education and career pathways to help broaden participation in science and engineering.

8. **Growing Convergence Research at NSF (GCR)—**Merging ideas, approaches, tools, and technologies from widely diverse fields of science and engineering to stimulate discovery and innovation.

9. **Mid-scale Research Infrastructure—**Developing an agile process for funding experimental research capabilities in the mid-scale range, spanning the midscale gap in research infrastructure between the $4 million cap on NSF's Major Research Instrumentation program and the $70 million lower bound for projects supported by NSF's Major Research Equipment and Facilities Construction account. This is a "sweet spot" for science and engineering that has been challenging to fund through traditional NSF programs.

10. **NSF 2026 Fund—**Stimulating and seeding investments in bold foundational research questions that are large in scope, innovative in character, originate outside of any particular NSF directorate, and may require a long-term commitment. This Big Idea is framed around the year 2026, providing an opportunity for transformative research to mark the Nation's 250th anniversary.

Big Ideas Stewardship Funding Model

The fundamental research underlying the Big Ideas has been supported through many NSF programs for a number of years, and in some cases, for decades. The FY 2019 Budget Request to Congress will accelerate NSF's progress on the Big Ideas through the following funding models:

Research Big Ideas. An investment of $30.0 million is requested for each of the six research Big Ideas, for a total investment of $180.0 million. These investments are in addition to the significant investments already being made by individual NSF directorates and offices in these areas. This additional investment for each of the Big Ideas will support convergent research that transcends traditional disciplinary boundaries of individual NSF directorates and offices. The research directions for a Big Idea will be overseen and managed collaboratively by the multi-directorate/office leadership of the corresponding Big Idea. Budget management and reporting will be the responsibility of the directorate to which the $30.0 million is assigned for a given Big Idea, with the multi-directorate/office leadership providing oversight.

Process Big Ideas. The process Big Ideas are also emphasized in this Budget Request:

- NSF INCLUDES will be funded at $20.0 million. The program will establish the NSF INCLUDES Alliances, as NSF begins to move the NSF INCLUDES program to national-scale collaborations;
- NSF 2026 will initiate mechanisms to catalyze new research areas that may become future research Big Ideas;
- GCR will support research programs that transcend two or more of the research Big Ideas, as NSF continues to break down barriers;
- An increased investment in mid-scale research infrastructure will be used to continue to span the midscale gap noted above.

Agency Reform

The landscape in which NSF executes its mission is constantly evolving. Today's research questions are increasingly interdisciplinary in nature, requiring new levels and forms of scientific and engineering collaboration. At the same time, the Nation is addressing pressing challenges, including maintaining the security of cyber systems and physical infrastructure, building resiliency to disasters, improving Americans' health and quality of life, educating and inspiring the next-generation workforce, and growing American jobs and economic productivity. To continue to achieve its mission, NSF must therefore adapt to this evolving environment.

In support of this adaptation, and in alignment with NSF's history of continued organizational improvement and the Administration's government-wide agency reform activities, NSF will focus reforms in five areas in FY 2019:

Convergence Accelerators. These are new organizational structures that represent an evolution from how funding for research has been organized at the agency. The Convergence Accelerators will be time-limited structural entities intended to leverage external partnerships to facilitate convergent and translational activities in areas of national importance. An investment of $60.0 million in FY 2019 will support two Convergence Accelerators pursuant to two of NSF's Big Ideas for Future Investment: HDR and FW-HTF. These Big Ideas were selected for the initial Convergence Accelerators because of their readiness for convergent and translational research. The $60.0 million investment by NSF is expected to catalyze an additional $40.0 million in investment by external partners, including the private sector, other federal agencies, and international funders. The Convergence Accelerators will be launched through NSF's Office of Integrative Activities.

As noted, the funding for the Convergence Accelerators will be separate from, and in addition to, the funding for the Big Ideas. The HDR and FW-HTF Convergence Accelerators will complement HDR and FW-HTF investments by NSF directorates and offices in existing, as well as new NSF programs, that are aligned with the goals of the HDR and FW-HTF Big Ideas. These programs have laid the foundations for the HDR and FW-HTF Convergence Accelerators, and will continue to be managed by NSF's directorates and offices. By continuing, and expanding, these foundational investments, NSF will be able to enhance meaningful progress in the corresponding areas. The results of these foundational investments will in turn feed the convergent and translational activities of the Convergence Accelerators, key to the success of the overall HDR and FW-HTF Big Ideas.

Make information technology (IT) work for us. For NSF to continue funding cutting-edge science and engineering, leading-edge IT solutions that can adapt easily and quickly are essential. NSF will work to ensure that IT tools enhance employee productivity and satisfaction by enabling access, through easy-to-use interfaces, to readily available, reliable, and fully integrated data to support decision making. For example, NSF will continue efforts started under its Proposal Management Efficiency (PME) activity to automate proposal processing and improve mission-critical systems in ways that reduce workload, increase operational efficiency, and serve our clients more effectively.

In FY 2019, NSF will invest an additional $4.0 million in adoption of automated, intelligent tools that enable evolution of NSF's business processes, including its core business process of merit review; and accelerated modernization of NSF's IT infrastructure via adoption of cloud offerings, consolidated computing platforms, software-defined network infrastructure, and automated change management processes to improve overall resilience of NSF's systems.

Align NSF's workforce and work. As the Nation's research enterprise evolves and NSF's proposal volume grows, the agency's workforce stands to benefit from enhanced capabilities that advance day-to-day business processes and enable the best service to the scientific community. In parallel with the IT-enabled business process improvements described above, NSF will optimize the alignment of staffing and position descriptions with the changing landscape. NSF will maintain its already lean workforce through continuous improvements in personnel training and utilization, and through effective performance management.

Expand public and private partnerships. Private industry, foundations, and non-profits, together with other federal agencies and international funding organizations, bring additional expertise, resources, and capacity to NSF-funded research, which can accelerate discovery and translation of research to products and services that benefit society and grow the American economy. NSF will improve efficiencies in developing, implementing, and managing partnerships that maximize the scientific, economic, and societal impacts of its investments. In particular, NSF will revise policies to enhance partnership development, including implementing new and innovative models with external organizations in science and engineering areas ripe for leverage. NSF will also explore additional partnerships with the private sector, philanthropies, and other federal agencies.

Streamline, standardize, and simplify programs and processes. Many NSF business processes are managed and executed locally within the agency's directorates and offices, posing efficiency and collaboration challenges. NSF will revise policies and business processes to increase standardization across NSF organizations and eliminate unnecessary complexity. There are significant opportunities for improvement relating to the merit review process, NSF's core business process, and expanded use of shared services for business operations.

Other Priorities

In FY 2019, NSF will make investments that support the basic research that advances human knowledge and make tomorrow's innovations possible. Additional investments will improve infrastructure in Antarctica, continue to protect the Nation's cyber assets, and improve artificial intelligence. In FY 2019, NSF expects that 91 percent of the annual budget will be used to fund research and education grants and research infrastructure in the science and education communities.

Basic research forms the core of NSF's work and has led to discoveries and innovations that have been awarded Nobel Prizes, and changed humankind's conception of the universe and known world. In FY 2019, NSF expects to invest $4.92 billion dollars, or 66 percent of NSF's total budget, in basic research. Basic research is responsible for advancing our knowledge of the universe, as well as innovations like high speed internet, nanotechnology, and advances in robotics that require understanding of the fundamental laws that govern the physical world. NSF funds basic research in all of the agency's directorates, and continues to fund research that transcends a single discipline.

The **Antarctic Infrastructure Modernization for Science (AIMS)** construction project is funded at $103.70 million in FY 2019. Antarctica makes up nearly nine percent of the continental mass of Earth's surface. NSF manages all U.S. activities as a single, integrated program, making Antarctic research possible for scientists supported by NSF and other U.S. agencies. Funding this infrastructure improvement project will protect U.S. interests on the continent. This will initiate modernization of major facilities at the aging McMurdo Station, so that anticipated science support needs are met for the next three to five decades. AIMS will enable faster, more streamlined logistical and science support by co-locating or consolidating warehousing, skilled trades work, and field science support where field projects are prepared for movement into the field, into four connected, enclosed buildings. AIMS will also provide necessary utilities to support these facilities. The total project cost is estimated to be $355 million, funded through the Research and Related Activities account.

Cybersecurity research ($160.55 million) protects and preserves the growing societal and economic benefits of cyber systems while ensuring preservation of individual privacy as well as usability. NSF-funded research will lead to advances in the scientific foundations underlying cybersecurity, including better understanding of the root causes of current threats and novel countermeasures to protect against them. It will also accelerate the meaningful transition to practice of cybersecurity tools and infrastructure, which will impact commercial products and policies in the long term, in alignment with the recent Presidential Executive Order on *Strengthening the Cybersecurity of Federal Networks and Critical Infrastructure*.

NSF has long supported fundamental research on **artificial intelligence (AI)**, or the study of computers and software capable of intelligent behavior. Today, NSF-funded AI research spans many sub-areas and includes both theoretical research and its application leading to integration of new capabilities into demonstrable systems and devices. A key goal is to understand how AI-based technologies will interface with humans. For example, NSF-funded work is advancing foundational techniques such as machine learning and neural networks, as well as domain areas including reasoning and representation, speech and language understanding, vision, computational neuroscience, robotics, and human augmentation. These advances, in turn, further education through intelligent tutoring systems, increase worker productivity with cognitive and physical aids, improve health with more accurate diagnosis and prediction, and enhance highway safety through assistive controls and forthcoming autonomous vehicles.

FY 2019 NSF-Wide 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 2019, NSF will support four continuing cross-Foundation investments.

FY 2019 Funding for Ongoing NSF-Wide Investments
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change Over FY 2017 Actual Amount	Change Over FY 2017 Actual Percent
Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS)	$55.79	-	$16.40	-$39.39	-70.6%
NSF Innovation Corps (I-Corps™)	29.85	-	30.00	0.15	0.5%
Secure and Trustworthy Cyberspace (SaTC)	136.53	-	129.00	-7.53	-5.5%
Understanding the Brain (UtB)	159.86	-	127.20	-32.66	-20.4%

Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS) ($16.40 million) 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. INFEWS is the first program to study the interconnected food-energy-water nexus. This program is driven by pressing needs and challenges, such as growing U.S. and global populations, changes in land use, and increasing geographic and seasonal variability in precipitation patterns, all of which are placing an ever-increasing stress on these 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. As part of a planned decrease in activities, support for INFEWS-related research is being migrated to the Big Ideas and programs across NSF. NSF began identifying key investments explicitly as part of the INFEWS initiative in FY 2016 and will continue as planned through FY 2020. In FY 2019 ENG, GEO, IA and OISE will continue with dedicated investment, and for other directorates funding for the INFEWS emphases will continue as part of the research core investment.

NSF Innovation Corps (I-Corps™) ($30.0 million) improves NSF-funded researchers' access to resources that can assist in bridging the gap between discoveries and technologies, helping to transfer knowledge to downstream technological applications and use at scale. In FY 2019, NSF will continue to support I-Corps™ Nodes and I-Corps™ Sites to further build, utilize, and sustain a national innovation ecosystem that helps researchers effectively identify viable market opportunities and augments the development of technologies, products, and processes that benefit the Nation. NSF will also continue to support I-Corps™ Teams who are provided access to the experiential entrepreneurial education and mentoring to determine the readiness to commercialize technologies resulting from NSF-funded research.

The **Secure and Trustworthy Cyberspace (SaTC)** ($129.0 million) investment 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 also focuses on the training of the next generation cybersecurity workforce, especially for government. This program aligns NSF's cybersecurity investments with the national cybersecurity strategy. While the agency's investment in SaTC will decrease slightly (-5.5 percent), NSF will maintain its investments in cybersecurity research

across all related core and crosscutting programs.

Understanding the Brain (UtB) ($127.20 million) encompasses ongoing cognitive science and neuroscience research and NSF's contributions to the ongoing Brain Research through Advancing Innovation and Neurotechnologies (BRAIN) Initiative. The goal of UtB is to enable scientific understanding of the full complexity of the brain, in action and in context. 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 brain, behavior, and environment interact; and how the brain can recover from lost functionality. Investments that address critical research questions relevant to UtB are also central to the Big Ideas activities. NSF consolidated ongoing investments in cognitive science, neuroscience, and the BRAIN initiative in FY 2014 and the targeted UtB effort will continue as planned through FY 2020. BIO maintains its commitment at the FY 2017 level, and all of the other directorates involved are continuing with reduced commitments in FY 2019 as the key areas are re-aligned into the research core as well as Big Ideas such as URoL, HDR, and FW-HTF.

Education and STEM Workforce

NSF's education and STEM workforce investment, centered in the Directorate for Education and Human Resources (EHR), funds activities that support students, teachers, faculty, researchers, and the public. The EHR investment in core STEM education research is critical to building the Nation's knowledge base for strategic and impactful STEM learning. NSF's investments for FY 2019 focus on the following priorities:

The **CyberCorps®: Scholarship for Service (SFS)** program ($55.0 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 U.S. higher education enterprise to continue to produce professionals in these fields to secure the Nation's cyberinfrastructure. FY 2019 activities will include engaging first- and second-year undergraduate students, with a focus on veterans.

Computer Science for All (CSforAll) ($20.0 million) will build on ongoing efforts to enable rigorous and engaging computer science education in schools across the Nation, to prepare the STEM workforce of the future. Funds will support the development of prototype instructional materials, scalable and sustainable professional development models, approaches to preservice preparation for computer science teachers, teacher resources, and the research to study their impact. CSforAll aims to provide high school teachers with the preparation, professional development, and ongoing support that they need to teach rigorous computer science courses and to give preK-8 teachers the instructional materials and preparation they need to integrate computer science and computational thinking into their teaching.

The **Improving Undergraduate STEM Education (IUSE)** ($102.50 million) initiative supports the development of the STEM and STEM-capable workforce by investing in the improvement of undergraduate STEM education, with a focus on attracting and retaining students and on degree completion. The initiative funds the development and implementation and the related research and assessment of effectiveness.

Through the **Advanced Technological Education (ATE)** ($66.0 million) program, NSF is able to reach technicians in undergraduate programs preparing for the high-technology fields that drive our Nation's economy.

The **Graduate Research Fellowship Program (GRFP)** ($270.72 million) recognizes students with high potential in STEM research and innovation and provides support for them to pursue research across all science and engineering disciplines. GRFP fellows may participate in Graduate Research Opportunities Worldwide (GROW), which provides opportunities to conduct research with international partner countries and organizations, and Graduate Research Internship Program (GRIP), which provides professional development through research internships at federal agencies. In FY 2019, NSF will support 1,500 new fellows.

Major Research Equipment and Facilities Construction

The FY 2019 Request includes funding to continue construction of the Daniel K. Inouye Solar Telescope, the Large Synoptic Survey Telescope, and the construction of two Regional Class Research Vessels. The total request to continue construction of both projects, as well as to fully fund oversight costs, is $94.95 million.

MREFC Account Funding, by Project
(Dollars in Millions)

	FY 2017 Actual	FY 2018 Request	FY 2019 Request
DKIST	$18.30	$20.00	$16.13
LSST	60.18	57.80	48.82
NEON	22.10	-	-
RCRV	121.88	105.00	28.70
Enhanced Oversight	0.33	-	1.00
Total	**$222.78**	**$182.80**	**$94.65**

The construction of **Daniel K. Inouye Solar Telescope** (DKIST) ($16.13 million) will enable the study of magneto-hydrodynamic phenomena in the solar photosphere, chromosphere, and corona. It will enable scientists to study these phenomena at unprecedented spatial, temporal, and wavelength resolutions. These phenomena are associated with what is generally known as space weather, which severely impact the Nation's infrastructure. FY 2019 will be the final year of funding in an 11-year funding profile.

The **Large Synoptic Survey Telescope** (LSST) ($48.82 million) will be an 8-meter-class wide-field optical telescope capable of carrying out surveys of the entire sky. It will collect nearly 40 terabytes of multi-color imaging data every night to produce the deepest, widest-field sky image ever. It will also issue alerts for moving and transient objects within 60 seconds of their discovery. FY 2019 will be year six of its nine-year construction funding profile.

The **Regional Class Research Vessel** (RCRV) ($28.70 million) project will fund construction of two ships. This project is a major component in the plan for modernizing the U.S. Academic Research Fleet. The RCRV will provide scientific infrastructure that enables increased understanding of: the potential impacts of geohazards, such as storm surges and tsunamis; transportation and recreation; natural resource identification and extraction; and fisheries and aquaculture, among many other topics.

Organizational Excellence

NSF seeks to integrate mission, vision, and core values to efficiently and effectively execute NSF's 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. The portfolio of activities included in Organizational Excellence addresses the agency's operations and administrative functions, which underpin NSF's programmatic activities.

Staffing

In FY 2019, NSF will work towards full utilization of its allocations of 1,442 FTE for federal staff and 168 FTE for staff hired under the Intergovernmental Personnel Act. The Foundation recognizes that maintaining staffing levels is vital to effectively and efficiently achieving its mission.

FY 2019 Summary

NSF's FY 2019 funding request for Organizational Excellence is $485.88 million, a decrease of $42.43 million, or 8.0 percent, below the FY 2017 Actual. The major reduction is in the Agency Operations and Award Management account as a result of the completion of the construction of, and relocation to, NSF's new headquarters building in Alexandria, Virginia and the lower cost of rent and utilities at the new building. Overall, Information Technology costs are relatively flat to FY 2017, and NSF will preserve secure, reliable information technology operations and continue to modernize the IT infrastructure and systems to the greatest extent funding allows. Within the Organizational Excellence portfolio in FY 2019, NSF will initiate operational reforms in four areas as discussed in the Agency Reform section of the Overview.

2018-2022 Strategic Plan and Performance

Integral to this submission is the NSF Strategic Plan for FY 2018-2022: *Building the Future: Investing in Discovery and Innovation*. 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 is built around three Strategic Goals:

- **Expand knowledge in science, engineering, and learning**. The first part of NSF's mission is "to promote the progress of science." By expanding human knowledge, NSF-funded researchers provide the Nation with the capability to maintain scientific, technological, and economic leadership in a competitive world.
- **Advance the capability of the Nation to meet current and future challenges**. This goal flows from the latter part of the NSF mission statement: "to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes." NSF uses a variety of approaches to promote impact-driven, use-inspired research. Innovation is a key capability for the Nation, and NSF's investments foster innovation across a broad range of topics relevant to technological and economic competitiveness.
- **Enhance NSF's performance of its mission**. Effectively fulfilling NSF's mission requires blending strong scientific leadership with robust organizational leadership. Both are characterized by vision and flexibility.

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 Objectives supporting each Strategic Goal.

Agency Priority Goal: Expand Public and Private Partnerships

NSF has set an Agency Priority Goal for completion by the end of FY 2019: "Expand public and private partnerships to enhance the impact of NSF's investments and contribute to American economic competitiveness and security." By September 30, 2019, NSF's number of partnerships and/or award actions with other federal agencies, private industry, and foundations/philanthropies will grow by five percent, relative to the FY 2017 baseline, to make available infrastructure, expertise, and financial resources to the U.S. scientific and engineering research and education enterprise.

Performance Plan

NSF embraces the use of goals to drive performance improvements. For FY 2019, NSF has set performance goals to strategically monitor and oversee progress being made toward its larger aims, as well as progress towards agency reform. NSF also assesses progress through an annual process of strategic reviews of the objectives in its Strategic Plan.

In FY 2019, in addition to goals monitoring the four aspects of reform described in the next section, NSF will monitor the following longstanding goals:

- **Ensure that Key Program Investments Are on Track:** Ensure that key FY 2019 NSF-wide program investments are implemented and on track.
- **Ensure that Infrastructure Investments Are on Track:** Ensure program integrity and responsible stewardship of major research facilities and infrastructure.

- **Make Timely Award Decisions:** Inform applicants whether their proposals have been declined or recommended for funding in a timely manner.
- **Foster a Culture of Inclusion:** Foster a culture of inclusion through management efforts resulting in leadership that is committed, knowledgeable, and accountable.

Lower-Priority Program Activities

NSF's FY 2019 Request follows a thorough examination of programs and investments across NSF to determine where the potential exists for more innovative investments. This Request includes four proposed terminations, totaling $302.03 million.

Cyber-enabled Materials, Manufacturing, and Smart Systems (CEMMSS) (-$296.25 million) was established in FY 2013 to integrate several science and engineering activities across NSF—breakthrough materials, advanced manufacturing, and smart systems, including robotic, cyber-physical, and autonomous systems. CEMMSS-funded research advanced materials with unique properties and functionality through the integration of theory, experiments, simulations, and data analytics. Further, using advanced manufacturing strategies, new materials were fashioned into objects, structures, and systems integrated with computational intelligence, thereby transforming static systems, processes, and edifices into adaptive, pervasive smart systems. CEMMSS will sunset in FY 2019 as it has achieved its programmatic goals. NSF will continue to develop several comprehensive, integrated programs across CEMMSS focus areas, such as cyber-manufacturing, advanced materials, and smart systems, including robotics, cyber-physical, and autonomous systems. These investments will encourage new cross-disciplinary connections and activities, resulting in novel discoveries and innovations with transformative societal and economic impacts.

BIO Doctoral Dissertation Improvement Grant (DDIG) (-$2.32 million) The BIO directorate's DDIG program supported awards in selected areas of the biological sciences. These grants provide partial support of doctoral dissertation research for improvement beyond the already existing project. The grants cover costs for doctoral candidates to participate in scientific meetings, to conduct research in specialized facilities or field settings, and to expand an existing body of dissertation research. Following a process of internal review and discussion regarding available resources, both the Divisions of Environmental Biology and Integrative Organismal Systems will no longer accept DDIG proposals. This decision was necessary because of increasing workload and changes in division priorities. This change is consistent with decisions made by other divisions in BIO, which have not participated in the DDIG competition for more than a decade.

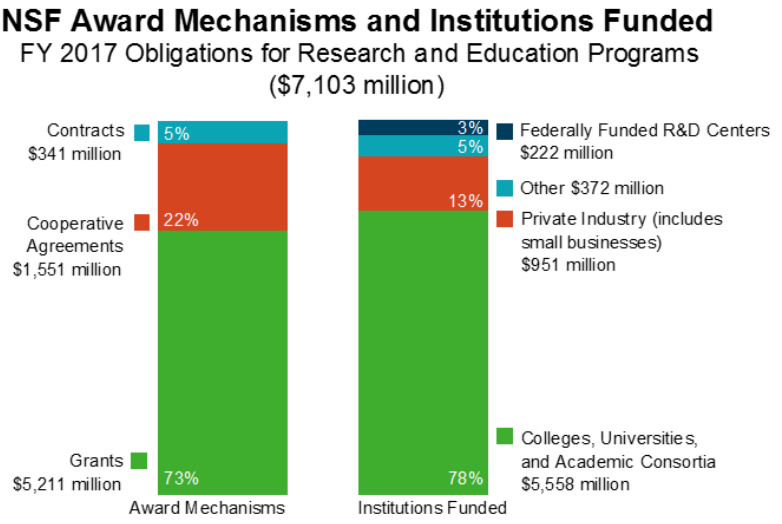
East Asia and Pacific Summer Institutes for U.S. Graduate Students (EAPSI) (-$960,000) The EAPSI program, established in 1990, provided support to introduce U.S. students to research in science and engineering in the East Asia-Pacific region and fostered student-initiated professional relationships to facilitate future collaboration. EAPSI will be terminated in FY 2019 because it will have met its stated objectives. Furthermore, beginning in FY 2015, OISE shifted emphasis from small-scale to larger-scale catalytic activities. OISE will continue to focus on funding projects that are larger-scale with greater impacts, and will adapt the best practices from the EAPSI program in future funding opportunities.

Information Technology Support Related to NSF Headquarters Relocation (-$2.50 million) This program achieved its stated goal in support of the NSF headquarters relocation support and stabilization in first quarter of FY 2018. Therefore, no additional funding is needed.

NSF by the Numbers

NSF by the Numbers: In FY 2019, NSF expects to evaluate approximately 50,600 proposals through a competitive merit review process and make approximately 11,100 new competitive awards, 8,400 of which will be new research grants and the remainder will be contracts and cooperative agreements. The number of new research grants decreases by roughly seven percent from previous levels, in keeping with the overall change in total NSF funding. This process involves approximately 250,000 proposal reviews, engaging on the order of 34,000 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 2019, NSF support is expected to reach approximately 354,850 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 2017, it is expected that the relative shares in FY 2019 will be similar. As shown on the graph, 95 percent of NSF's FY 2017 projects were funded using grants or cooperative agreements. NSF grants are either standard or continuing awards. That is, the award is made during one fiscal year for the full amount of the award, or made over several years 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.). Contracts are used to acquire products, services, and studies (e.g., program evaluations) required primarily for NSF or other government use.



Notes: NSF Research and Education Programs include—Research & Related Activities, Education & Human Resources, and Major Research Equipment & Facilities Construction appropriations.

Other institutions funded include federal, state, and local governments; nonprofit organizations; and international organizations.

R&D = Research and Development.

Totals may not add due to rounding.

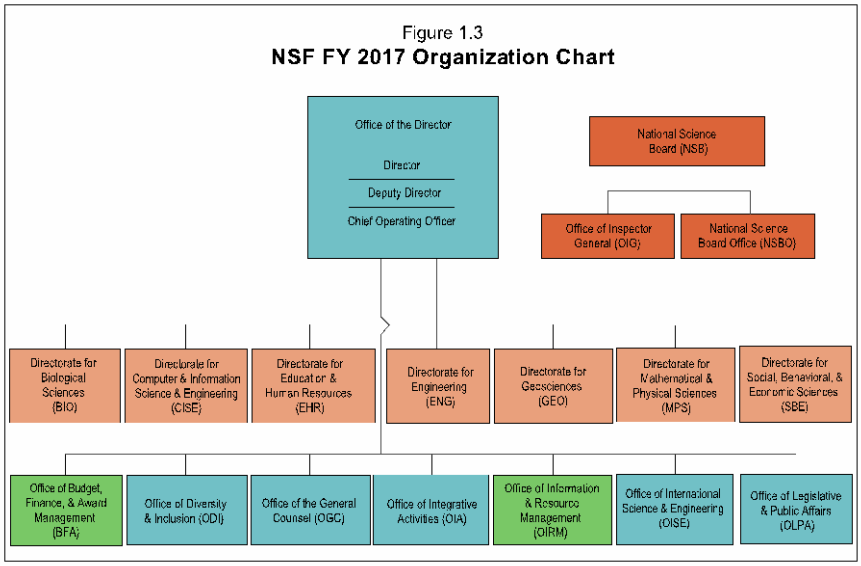
Most NSF awards are to academic institutions. As shown in the chart, 78 percent of support for research and education programs ($5,558 million) was to colleges (including two-year and community colleges), universities, and academic consortia. Private industry, including small businesses, accounted for 13 percent ($951 million), and support to Federally Funded Research and Development Centers (FFRDCs) accounted for three percent ($222 million). Other recipients included federal, state, and local governments; nonprofit organizations; and international organizations. A small number of awards fund research in collaboration with other countries, which adds value to the U.S. scientific enterprise and maintains U.S. leadership in the global scientific enterprise.

The chart on the left presents a high-level, agency-wide estimate of funding rates, or proposal "success," as a comparison of the number of competitive proposals, new awards, and funding rate between FY 2017, FY 2018, and FY 2019. This indicator is useful in gauging the relative impact of different funding levels. In FY 2019, NSF expects to make approximately 11,100 new awards, which corresponds to a funding rate of about 22 percent.

Organization and Role in the Federal Research Enterprise

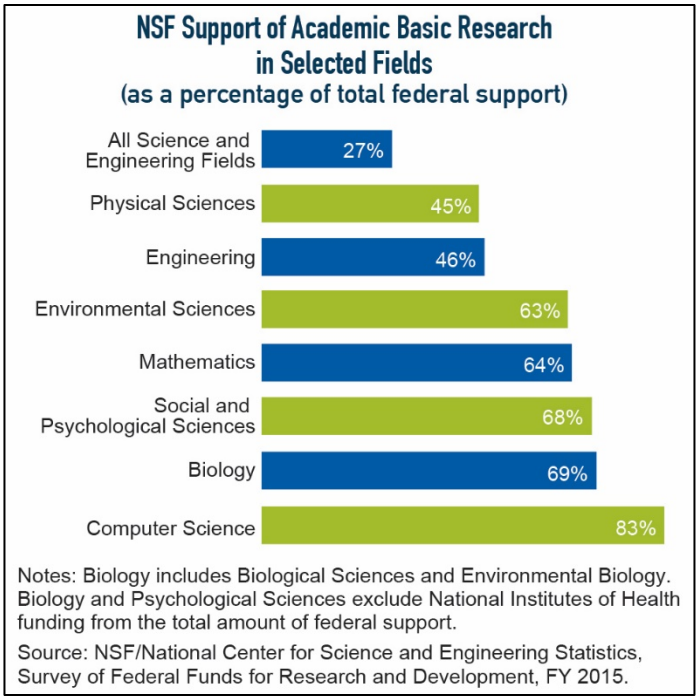
NSF's comprehensive and flexible support of meritorious projects enables the Foundation to identify and foster both fundamental and transformative discoveries and broader impacts within and among fields of inquiry. NSF has the latitude to support emerging fields, high-risk ideas, interdisciplinary collaborations,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

Figure 1.3
NSF FY 2017 Organization Chart



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, integrative activities, and international science and engineering. The 25-member National Science Board approves the overall policies of the Foundation.

NSF's annual budget represents approximately 27 percent of the total federal budget for basic research conducted at U.S. colleges and universities, and this share increases to approximately 60 percent when medical research supported by the National Institutes of Health is excluded. In many science and engineering fields, NSF is the primary source of federal academic support.



Highlights

For over 60 years, NSF has invested 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 a few examples of the important advances that NSF funding enables.

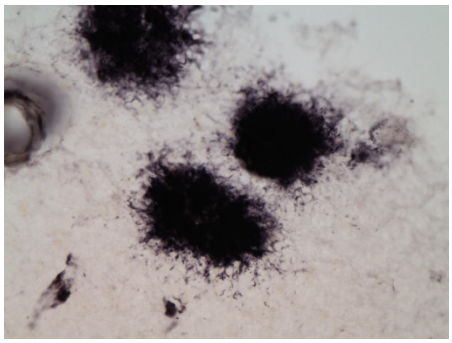
Ultrasensitive detector for physics and medicine

Novel magnetic sensors can speed diagnosis of heart, brain, and fetal conditions.
Credit: iStock.com/Pitju

NSF-funded research to discover fundamental particles and forces has led to a new tool with applications including brain research, diagnosis of abnormal heart rhythms, and pre-surgical imaging. Originally built to precisely measure very faint magnetic fields for basic physics experiments, the ultrasensitive detector, called an atomic spin magnetometer, has validated fundamental theories about the symmetry of space. Furthermore, the device's ability to sense magnetic fields 1,000 times weaker than those in the human brain made it a candidate for additional applications in medicine and neuroscience. Two startup companies, TwinLeaf Precision Sensors and QuSpin, are advancing the technology for commercial use.

New research detects Alzheimer's disease markers in nonhuman primates

NSF-funded researchers discovered proteins associated with Alzheimer's disease–believed to be unique to humans–in a sample of brains of aged chimpanzees. It has been suggested that humans are uniquely susceptible to Alzheimer's, potentially because of genetic differences from other primates, changes to the human brain during evolution, and longer lifespans. Understanding these differences can provide key insights into identifying the causes of Alzheimer's and working towards a cure. The identification in the aged chimpanzees of amyloid beta and tau lesions, hallmarks of Alzheimer's diagnosis, is a significant advancement in understanding the brain and Alzheimer's.

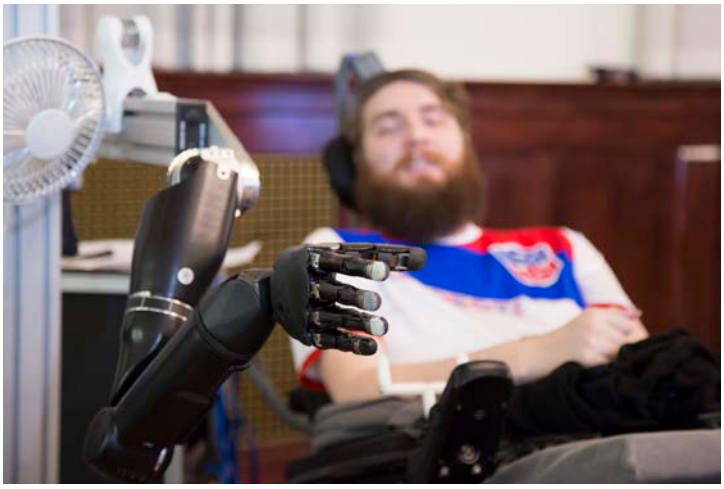


Amyloid beta plaques in the brain of a 58-year-old female chimpanzee.
Credit: Mary Ann Raghanti, Kent State University

Highlights

Quadriplegic ‘feels’ again thanks to brain-computer interface and robotic arm combination

From buttoning a shirt to grasping a cup, the ability to manipulate objects is aided by the sense of touch, which is why traditional prosthetics can only provide patients with very limited functions. Earlier this year, a quadriplegic man experienced the sense of touch again through a robotic arm connected to a brain-computer interface (BCI) implanted in his head that allowed him to “feel” pressure on the robotic hand. The blueprint for the BCI-robotic arm system came from NSF-funded basic research that examined the neural activity of monkeys as they manipulated objects. The advancement is paving the way for future touch-sensitive prosthetics.



A man manipulates a robotic arm via a computer chip in his brain.
Credit: University of Pittsburgh Medical Center/Pitt Health Sciences

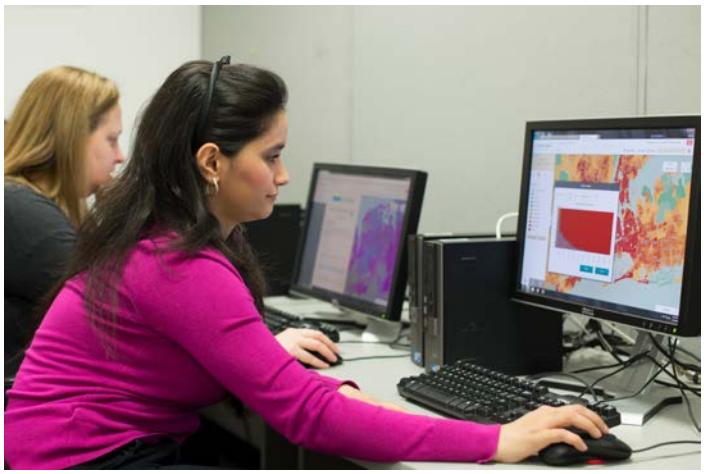
VLA reveals distant galaxy’s magnetic field

With the help of a gigantic cosmic lens, astronomers have measured the magnetic field of a galaxy nearly five billion light-years away. The achievement is giving them important new clues about a problem at the frontiers of cosmology—the nature and origin of the magnetic fields that play an important role in how galaxies develop over time. The scientists used NSF’s Karl G. Jansky Very Large Array (VLA) to study a star-forming galaxy that lies directly between a more-distant quasar and Earth. The galaxy’s gravity serves as a giant lens, splitting the quasar’s image into two separate images as seen from Earth. The radio waves coming from this quasar, nearly 8 billion light-years away, are preferentially aligned, or polarized. This discovery provides an important clue about how galactic magnetic fields are formed and evolve over time.

Artist’s conception of a gravitational lens arrangement that allowed astronomers to measure galaxy’s magnetic field.
Credit: Bill Saxton, NRAO/AUI/NSF; NASA, Hubble Heritage Team, STScI/AURA), ESA, S. Beckwith (STScI). Additional Processing: Robert Gendler

Highlights

Development of online visualization tool adopted by Census Bureau



Undergraduate sociology students use Social Explorer to visualize census data.
Credit: Aisha Hassan, Queens College, CUNY

The U.S. Census Bureau's Census Explorer is an online, interactive mapping tool that enables members of the media and public to visualize census data at the state, county and neighborhood levels. The web-based platform is built on a data visualization tool, called Social Explorer, developed by an NSF-funded researcher to help undergraduate sociology students studying demography better visualize U.S. census data. Census Explorer users can create maps on a range of data, including median household income and home ownership rate. Within the first few months of the tool's launch, more than 100,000 users had created four million data maps.

Eight ways the National Science Foundation supports our troops

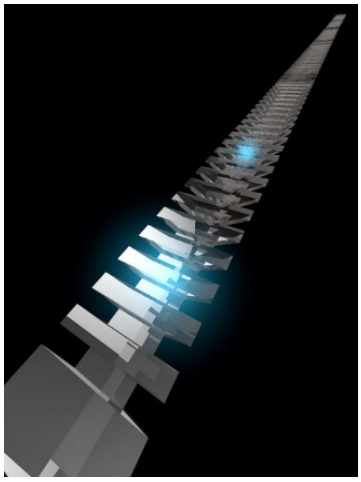
Since we were founded, securing the national defense has been a key part of the NSF mission. In recent years, we have lived up to that responsibility by funding research on building a stronger bulletproof vest, countering violent extremism, creating better GPS technology and improving prosthetics with brain-computer interface. Our support has also gone towards minimizing blood loss in battle wounds, helping military veterans with PTSD, detecting explosives and predicting conflict. NSF is proud of the role it plays in keeping American soldiers safe and military technology on the cutting-edge.

University of Maryland's brain cap technology. Alessandro Presacco, a graduate researcher in UMD's Neural Engineering and Smart Prosthetics Lab, adjusts a version of Brain Cap headset worn by Steve Graff, a bioengineering doctoral student. Looking on is lab director and Brain Cap creator José 'Pepe' Contreras-Vidal.
Credit: John Consoli, University of Maryland

Highlights

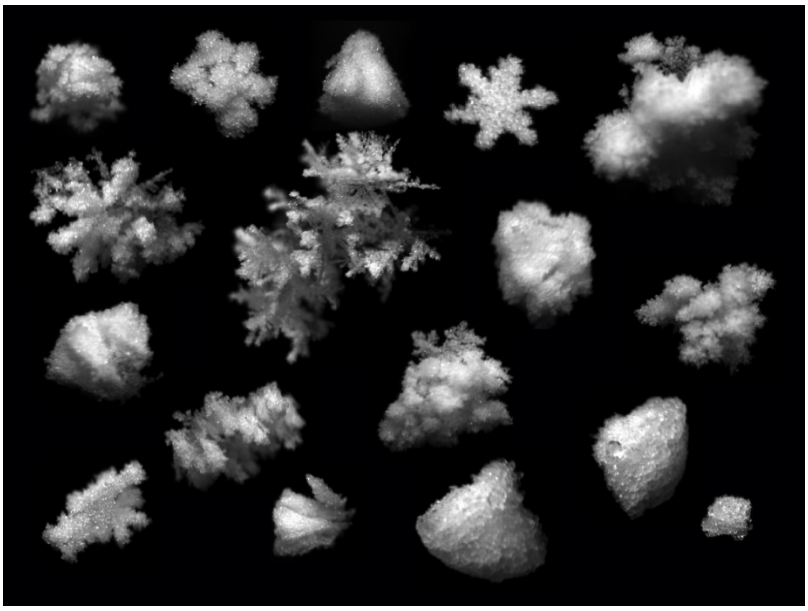
First on-chip nanoscale optical quantum memory developed

NSF-funded researchers have built the first nanoscale optical quantum memory device that could one day be used to create more reliable and secure internet communications. Quantum memory stores information in a similar fashion to the way traditional computer memory does, but on individual quantum particles—in this case, photons of light. This method takes advantage of the peculiar features of quantum mechanics to store data more efficiently and securely. The use of individual photons to store and transmit data has long been a goal of engineers and physicists because of the potential to carry information reliably and securely. Because photons lack charge and mass, they can be transmitted across a fiber optic network with minimal interactions with other particles.



Artist's rendition of Faraon's quantum memory device.
Credit: Ella Maru Studio

Safer winter driving with snowflake imaging



A high-speed, three-camera system reveals formation of an ice pellet.
Credit: Tim Garrett, University of Utah

Falling snow makes winter driving a challenge. Transportation planners, road crews and emergency managers can now estimate real-time accumulations with active imaging from multi-angle snowflake cameras (MASC). NSF-funded research led to the development of MASC, which images snowflakes down to the diameter of a human hair and simultaneously measures how fast they fall. These data have been critical for verifying snowfall predictions and winter precipitation algorithms for weather radars.

SUMMARY TABLES

Total NSF Funding:

Major NSF-wide Investments:

STEM Education and Workforce:

Research Infrastructure:

NATIONAL SCIENCE FOUNDATION
SUMMARY TABLE
FY 2019 BUDGET REQUEST TO CONGRESS
(Dollars in Millions)

NSF by Account	FY 2017 Actual	FY 2018 Annualized CR	FY 2019 Request	FY 2019 Request change over FY 2017 Actual Amount	Percent
BIO	$742.22	-	$738.16	-$4.06	-0.5%
CISE	935.93	-	925.42	-10.51	-1.1%
ENG	930.92	-	921.43	-9.49	-1.0%
Eng Programs	*731.87*	*-*	*722.86*	*-9.01*	*-1.2%*
SBIR/STTR	*199.05*	*-*	*198.57*	*-0.48*	*-0.2%*
GEO	825.62	-	852.98	27.36	3.3%
MPS	1,362.43	-	1,345.32	-17.11	-1.3%
SBE	270.89	-	246.19	-24.70	-9.1%
SBE Programs	*219.70*	*-*	*195.00*	*-24.70*	*-11.2%*
NCSES	*51.19*	*-*	*51.19*	*-*	*-*
OISE	48.96	-	48.50	-0.46	-0.9%
OPP	467.85	-	534.54	66.69	14.3%
IA	420.27	-	536.72	116.45	27.7%
U.S. Arctic Research Commission	1.43	-	1.42	-0.01	-0.7%
Research & Related Activities	**$6,006.51**	**$5,992.67**	**$6,150.68**	**$144.17**	**2.4%**
Education & Human Resources	**$873.37**	**$874.02**	**$873.37**	**-**	**-**
Major Research Equipment & Facilities Construction	**$222.78**	**$207.58**	**$94.65**	**-$128.13**	**-57.5%**
Agency Operations & Award Management	**$382.06**	**$327.76**	**$333.63**	**-$48.43**	**-12.7%**
National Science Board	**$4.27**	**$4.34**	**$4.32**	**$0.05**	**1.2%**
Office of Inspector General	**$15.10**	**$15.10**	**$15.35**	**$0.25**	**1.6%**
Total, NSF	**$7,504.10**	**$7,421.47**	**$7,472.00**	**-$32.10**	**-0.4%**

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.

Statistics for Research Grant Awards: Research Grant Awards are a sub-set of competitive awards. They are limited to research projects and exclude other categories of awards such as those for 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 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. Annualized Award Size shows the annual level of research grant awards provided to awardees by dividing the total dollars of each award by the number of years over which it extends. Average Duration is the length of awards in years.

NSF Funding Profile

	FY 2017 Actual Estimate	FY 2018 (TBD)	FY 2019 Request Estimate
Statistics for Competitive Awards			
Number of Proposals	49,300	-	50,600
Number of Awards	11,400	-	11,100
Funding Rate	23%	-	22%
Statistics for Research Grant Awards		-	
Number of Research Grant Proposals	40,600	-	42,100
Number of Research Grant Awards	8,600	-	8,400
Funding Rate	21%	-	20%
Median Annualized Award Size	$140,300	-	$140,900
Average Annualized Award Size	$172,400	-	$175,700
Average Duration (years)	2.9	-	2.9

NUMBER OF PEOPLE INVOLVED IN NSF ACTIVITIES

NSF estimates that in FY 2019 approximately 354,850 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 2019 Request
Number of People Involved in NSF Activities

	FY 2017 Actual Estimate	FY 2018 (TBD)	FY 2019 Estimate
Senior Researchers	41,910	-	41,080
Other Professionals	13,832	-	13,430
Postdoctoral Associates	5,665	-	5,420
Graduate Students	41,038	-	40,320
Undergraduate Students	38,384	-	37,800
K-12 Teachers	40,436	-	40,400
K-12 Students	178,053	-	176,400
Total Number of People	**359,318**	**-**	**354,850**

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. These individuals are supported through funds included in research projects, centers, or facilities awards, as well as by postdoctoral fellowships.

Graduate Students include those compensated from NSF grant funds. Approximately 17 percent receive support through NSF's fellowship and traineeship programs. Other graduate students 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 30 percent of the U.S. science and engineering graduate students receiving federal funds and about five 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 2016: Chapter 2 Higher Education in Science and Engineering, Appendix Tables 02-07 and 02-11. Retrieved from www.nsf.gov/statistics/2016/nsb20161/#/data

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 2019

(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	5,989.68	962.57	878.97	200.31	218.31	354.84	357.00	15.16	15.16	4.37	4.37	7,723.55	7,463.49
2017	6,425.44	6,005.65	952.86	873.05	193.12	214.86	373.02	359.09	15.20	15.20	4.38	4.37	7,964.02	7,472.22
2018	5,361.65	-	760.55	-	182.80	-	328.51	-	15.01	-	4.37	-	6,652.89	-
2019	6,150.68	-	873.37	-	94.65	-	333.63	-	15.35	-	4.32	-	7,472.00	-

Appropriations as shown are post-transfer.

[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.

NSF's 10 BIG IDEAS FY 2019 REQUEST FUNDING

(Dollars in Millions)

Big Ideas	FY 2019 Request
Research Ideas	**$180.00**
Harnessing the Data Revolution for 21st- Century Science and Engineering - HDR (CISE/ITR)[1]	30.00
Navigating the New Arctic - NNA (GEO/ICER)	30.00
The Future of Work at the Human-Technology Frontier - FW-HTF (ENG/EFMA)[1]	30.00
The Quantum Leap - QL (MPS/OMA)	30.00
Understanding the Rules of Life - URoL (BIO/EF)	30.00
Windows on the Universe - WoU (MPS/OMA)	30.00
Process Ideas	**$102.50**
Growing Convergence Research - GCR (IA)	16.00
Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science - NSF INCLUDES (EHR)	20.00
Mid-Scale Research Infrastructure (IA)	60.00
NSF 2026 Fund (IA)	6.50
Total, NSF Big Ideas	**$282.50**

[1]Convergence Accelerator funding will also support the Big Ideas HDR and FW-HTF in the amount of $30 million for each, in addition to the amounts above. The Convergence Accelerator funding will be managed by IA, and the Research Ideas funding will be managed by CISE and ENG, respectively, as shown above. For more information on Convergence Accelerators, refer to the Agency Reform section of the Overview chapter. For more information on NSF's Big Ideas, refer to the Big Ideas section of the Overview chapter.

NATIONAL SCIENCE FOUNDATION
SELECTED CROSSCUTTING PROGRAMS
FY 2019 BUGET REQUEST TO CONGRESS
(Dollars in Millions)

Selected Cross-Cutting Programs		FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	FY 2019 Request change over FY 2017 Actual Amount	Percent
ADVANCE	Research & Related Activities	16.47	-	-	-16.47	-100.0%
	Education & Human Resources	1.53	-	18.00	16.47	1074.2%
	Total, NSF	**$18.00**	**-**	**$18.00**	**-$0.00**	**-0.0%**
Faculty Early Career Development - CAREER	Research & Related Activities	283.44	-	252.43	-31.01	-10.9%
	Education & Human Resources	-	-	-	-	N/A
	Total, NSF	**$283.44**	**-**	**$252.43**	**-$31.01**	**-10.9%**
Graduate Research Fellowship Program - GRFP	Research & Related Activities	160.79	-	135.36	-25.43	-15.8%
	Education & Human Resources	158.70	-	135.36	-23.34	-14.7%
	Total, NSF	**$319.48**	**-**	**$270.72**	**-$48.76**	**-15.3%**
NSF Research Traineeship - NRT	Research & Related Activities	21.89	-	10.95	-10.94	-50.0%
	Education & Human Resources	30.97	-	41.19	10.22	33.0%
	Total, NSF	**$52.86**	**-**	**$52.14**	**-$0.72**	**-1.4%**
Total, Graduate Fellowships & Traineeships	Research & Related Activities	182.68	-	146.31	-36.37	-19.9%
	Education & Human Resources	189.67	-	176.55	-13.12	-6.9%
	Total, NSF	**$372.35**	**-**	**$322.86**	**-$49.49**	**-13.3%**
Long-Term Ecological Research Sites - LTERs	Research & Related Activities	30.90	-	29.05	-1.85	-6.0%
	Education & Human Resources	-	-	-	-	N/A
	Total, NSF	**$30.90**	**-**	**$29.05**	**-$1.85**	**-6.0%**
Research Experiences for Undergraduates - REU - Sites Only	Research & Related Activities	70.26	-	60.94	-9.32	-13.3%
	Education & Human Resources	-	-	-	-	N/A
	Total, NSF	**$70.26**	**-**	**$60.94**	**-$9.32**	**-13.3%**
Research Experiences for Undergraduates - REU - Supplements Only	Research & Related Activities	24.01	-	19.10	-4.91	-20.4%
	Education & Human Resources	-	-	-	-	N/A
	Total, NSF	**$24.01**	**-**	**$19.10**	**-$4.91**	**-20.4%**
Total, Research Experiences for Undergraduates - REU	Research & Related Activities	94.26	-	80.04	-14.22	-15.1%
	Education & Human Resources	-	-	-	-	N/A
	Total, NSF	**$94.26**	**-**	**$80.04**	**-$14.22**	**-15.1%**
Research in Disabilities Education - RDE	Research & Related Activities	0.31	-	-	-0.31	-100.0%
	Education & Human Resources	11.60	-	6.50	-5.10	-44.0%
	Total, NSF	**$11.91**	**-**	**$6.50**	**-$5.41**	**-45.4%**
Research in Undergraduate Institutions - RUI	Research & Related Activities	43.97	-	33.39	-10.58	-24.1%
	Education & Human Resources	-	-	-	-	N/A
	Total, NSF	**$43.97**	**-**	**$33.39**	**-$10.58**	**-24.1%**

NATIONAL SCIENCE FOUNDATION
NSTC CROSSCUTS SUMMARY
FY 2019 BUDGET REQUEST TO CONGRESS

(Dollars in Millions)

National Nanotechnology Initiative (NNI)					
				FY 2019 Request change over FY 2017 Actual	
	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Amount	Percent
BIO	$48.80	-	$42.50	-$6.30	-12.9%
CISE	11.24	-	10.60	-0.64	-5.7%
ENG	207.10	-	168.50	-38.60	-18.6%
GEO	0.30	-	-	-0.30	-100.0%
MPS	195.11	-	163.09	-32.02	-16.4%
SBE	0.53	-	0.40	-0.13	-23.8%
OISE	0.10	-	0.10	-	-
R&RA	**$463.17**	**-**	**$385.19**	**-$77.98**	**-16.8%**
EHR	**$2.50**	**-**	**$2.50**	**-**	**-**
NSF Total	**$465.67**	**-**	**$387.69**	**-$77.98**	**-16.7%**

Networking & Information Technology R&D (NITRD)					
				FY 2019 Request change over FY 2017 Actual	
	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Amount	Percent
BIO	$99.00	-	$67.00	-$32.00	-32.3%
CISE	935.93	-	925.42	-10.51	-1.1%
ENG	15.82	-	23.25	7.43	47.0%
GEO	24.00	-	22.00	-2.00	-8.3%
MPS	125.24	-	82.14	-43.10	-34.4%
SBE	28.23	-	22.71	-5.52	-19.6%
R&RA	**$1,228.22**	**-**	**$1,142.52**	**-$85.70**	**-7.0%**
EHR	**$9.50**	**-**	**$9.50**	**-**	**-**
NSF Total	**$1,237.72**	**-**	**$1,152.02**	**-$85.70**	**-6.9%**

U.S. Global Change Research Program (USGCRP)					
				FY 2019 Request change over FY 2017 Actual	
	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Amount	Percent
BIO	$79.26	-	$90.00	$10.74	13.6%
GEO	130.00	-	120.00	-10.00	-7.7%
MPS	0.50	-	-	-0.50	-100.0%
SBE	17.98	-	13.18	-4.80	-26.7%
OPP	15.15	-	15.15	-	-
R&RA	**$242.89**	**-**	**$238.33**	**-$4.56**	**-1.9%**
EHR	**-**	**-**	**-**	**-**	**N/A**
NSF Total	**$242.89**	**-**	**$238.33**	**-$4.56**	**-1.9%**

NATIONAL SCIENCE FOUNDATION
NATIONAL NANOTECHNOLOGY INITIATIVE SUMMARY
FY 2019 BUDGET REQUEST TO CONGRESS
(Dollars in Millions)

	BIO	CISE	ENG	GEO	MPS	SBE	OISE	RRA	EHR	Total, NSF
Total, FY 2017 Actual	**$48.80**	**$11.24**	**$207.10**	**$0.30**	**$195.11**	**$0.53**	**$0.10**	**$463.17**	**$2.50**	**$465.67**
NNI Grand Challenge (GC) and Signature Initiative (NSI) Total	-	4.40	104.50	-	56.72	-	-	165.62	-	165.62
Nanotechnology-Inspired Grand Challenge for Future Computing	-	*4.40*	*5.00*	-	*20.00*	-	-	*29.40*	-	*29.40*
Nanoelectronics for 2020 and Beyond	-	-	*31.50*	-	*12.00*	-	-	*43.50*	-	*43.50*
Nanotechnology for Sensors and Sensors for Nanotechnology	-	-	*9.50*	-	*5.10*	-	-	*14.60*	-	*14.60*
Nanotechnology Knowledge Infrastructure	-	-	*16.50*	-	*6.00*	-	-	*22.50*	-	*22.50*
Sustainable Nanomanufacturing	-	-	*30.00*	-	*9.62*	-	-	*39.62*	-	*39.62*
Water Sustainability through Nanotechnology	-	-	*12.00*	-	*4.00*	-	-	*16.00*	-	*16.00*
Environment, Health, and Safety	6.30	-	9.00	-	4.56	0.13	-	19.99	-	19.99
Foundational Research	40.00	3.62	34.10	-	106.67	-	-	184.39	-	184.39
Nanotechnology-Enabled Applications, Devices, and Systems	-	2.12	38.50	-	2.46	-	-	43.08	-	43.08
Research Infrastructure and Instrumentation	2.50	1.10	21.00	0.30	24.70	0.40	0.10	50.10	2.50	52.60
Delta from FY 2017 Actual to FY 2019 Request	**-$6.30**	**-$0.64**	**-$38.60**	**-$0.30**	**-$32.02**	**-$0.13**	**-**	**-$77.98**	**-**	**-$77.98**
NNI Grand Challenge (GC) and Signature Initiative (NSI) Total	-	-0.25	-17.00	-	-37.22	-	-	-54.47	-	-54.47
Nanotechnology-Inspired Grand Challenge for Future Computing	-	*-0.25*	*3.00*	-	*-19.00*	-	-	*-16.25*	-	*-16.25*
Nanoelectronics for 2020 and Beyond	-	-	*-13.00*	-	*1.50*	-	-	*-11.50*	-	*-11.50*
Nanotechnology for Sensors and Sensors for Nanotechnology	-	-	*-3.50*	-	*-3.60*	-	-	*-7.10*	-	*-7.10*
Nanotechnology Knowledge Infrastructure	-	-	*2.50*	-	*-5.50*	-	-	*-3.00*	-	*-3.00*
Sustainable Nanomanufacturing	-	-	*-4.00*	-	*-7.62*	-	-	*-11.62*	-	*-11.62*
Water Sustainability through Nanotechnology	-	-	*-2.00*	-	*-3.00*	-	-	*-5.00*	-	*-5.00*
Environment, Health, and Safety	-6.30	-	-	-	-3.01	-0.13	-	-9.44	-	-9.44
Foundational Research	-	-0.22	-6.10	-	7.30	-	-	0.98	-	0.98
Nanotechnology-Enabled Applications, Devices, and Systems	-	-0.12	-6.50	-	1.54	-	-	-5.08	-	-5.08
Research Infrastructure and Instrumentation	-	-0.05	-9.00	-0.30	-0.63	-	-	-9.98	-	-9.98
Total, FY 2019 Request	**$42.50**	**$10.60**	**$168.50**	**-**	**$163.09**	**$0.40**	**$0.10**	**$385.19**	**$2.50**	**$387.69**
NNI Grand Challenge (GC) and Signature Initiative (NSI) Total	-	4.15	87.50	-	19.50	-	-	111.15	-	111.15
Nanotechnology-Inspired Grand Challenge for Future Computing	-	*4.15*	*8.00*	-	*1.00*	-	-	*13.15*	-	*13.15*
Nanoelectronics for 2020 and Beyond	-	-	*18.50*	-	*13.50*	-	-	*32.00*	-	*32.00*
Nanotechnology for Sensors and Sensors for Nanotechnology	-	-	*6.00*	-	*1.50*	-	-	*7.50*	-	*7.50*
Nanotechnology Knowledge Infrastructure	-	-	*19.00*	-	*0.50*	-	-	*19.50*	-	*19.50*
Sustainable Nanomanufacturing	-	-	*26.00*	-	*2.00*	-	-	*28.00*	-	*28.00*
Water Sustainability through Nanotechnology	-	-	*10.00*	-	*1.00*	-	-	*11.00*	-	*11.00*
Environment, Health, and Safety	-	-	9.00	-	1.55	-	-	10.55	-	10.55
Foundational Research	40.00	3.40	28.00	-	113.97	-	-	185.37	-	185.37
Nanotechnology-Enabled Applications, Devices, and Systems	-	2.00	32.00	-	4.00	-	-	38.00	-	38.00
Research Infrastructure and Instrumentation	2.50	1.05	12.00	-	24.07	0.40	0.10	40.12	2.50	42.62

NATIONAL SCIENCE FOUNDATION
NETWORKING AND INFORMATION TECHNOLOGY R&D SUMMARY
FY 2019 BUDGET REQUEST TO CONGRESS
(Dollars in Millions)

	BIO	CISE	ENG	GEO	MPS	SBE	RRA	EHR	Total, NSF
Total, FY 2017 Actual	**$99.00**	**$935.93**	**$15.82**	**$24.00**	**$125.24**	**$28.23**	**$1,228.22**	**$9.50**	**$1,237.72**
Computing-Enabled Human Interaction, Communications, Augmentation	-	80.52	-	-	-	13.24	93.76	-	93.76
Computing-Enabled Networked Physical Systems	1.00	75.88	-	-	-	-	76.88	-	76.88
Cyber Security & Privacy	-	104.39	3.61	-	1.03	5.74	114.77	-	114.77
Education and Workforce	6.00	61.91	-	-	-	-	67.91	9.50	77.41
Enabling-R&D for High-Capability Computing System	-	109.88	-	-	42.02	-	151.90	-	151.90
High Capability Computing Infrastructure and Applications	2.50	120.08	-	24.00	70.89	-	217.47	-	217.47
Intelligent Robotics and Autonomous Systems	-	35.20	7.21	-	-	-	42.41	-	42.41
Large-Scale Data Management and Analysis	69.50	147.62	5.00	-	11.30	6.95	240.37	-	240.37
Large Scale Networking	-	136.80	-	-	-	-	136.80	-	136.80
Software Productivity, Sustainability and Quality	20.00	63.65	-	-	-	2.30	85.95	-	85.95
Delta from FY 2017 Actual to FY 2019 Request	**-$32.00**	**-$10.51**	**$7.43**	**-$2.00**	**-$43.10**	**-$5.52**	**-$85.70**	**-**	**-$85.70**
Computing-Enabled Human Interaction, Communications, Augmentation	-	-3.82	-	-	-	-3.86	-7.68	-	-7.68
Computing-Enabled Networked Physical Systems	-	-3.60	9.00	-	-	-	5.40	-	5.40
Cyber Security & Privacy	-	-4.95	-2.61	-	0.97	-1.74	-8.33	-	-8.33
Education and Workforce	-	0.92	-	-	-	-	0.92	-	0.92
Enabling-R&D for High-Capability Computing System	-	-5.21	-	-	-25.02	-	-30.23	-	-30.23
High Capability Computing Infrastructure and Applications	-	-5.69	-	-2.00	-18.89	-	-26.58	-	-26.58
Intelligent Robotics and Autonomous Systems	-	-1.67	1.04	-	-	-	-0.63	-	-0.63
Large-Scale Data Management and Analysis	-26.50	23.01	-	-	-0.16	0.24	-3.41	-	-3.41
Large Scale Networking	-	-6.48	-	-	-	-	-6.48	-	-6.48
Software Productivity, Sustainability and Quality	-5.50	-3.02	-	-	-	-0.16	-8.68	-	-8.68
Total, FY 2019 Request	**$67.00**	**$925.42**	**$23.25**	**$22.00**	**$82.14**	**$22.71**	**$1,142.52**	**$9.50**	**$1,152.02**
Computing-Enabled Human Interaction, Communications, Augmentation	-	76.70	-	-	-	9.38	86.08	-	86.08
Computing-Enabled Networked Physical Systems	1.00	72.28	9.00	-	-	-	82.28	-	82.28
Cyber Security & Privacy	-	99.44	1.00	-	2.00	4.00	106.44	-	106.44
Education and Workforce	6.00	62.83	-	-	-	-	68.83	9.50	78.33
Enabling-R&D for High-Capability Computing System	-	104.67	-	-	17.00	-	121.67	-	121.67
High Capability Computing Infrastructure and Applications	2.50	114.39	-	22.00	52.00	-	190.89	-	190.89
Intelligent Robotics and Autonomous Systems	-	33.53	8.25	-	-	-	41.78	-	41.78
Large-Scale Data Management and Analysis	43.00	170.63	5.00	-	11.14	7.19	236.96	-	236.96
Large Scale Networking	-	130.32	-	-	-	-	130.32	-	130.32
Software Productivity, Sustainability and Quality	14.50	60.63	-	-	-	2.14	77.27	-	77.27

NATIONAL SCIENCE FOUNDATION
U.S. GLOBAL CHANGE RESEARCH PROGRAM SUMMARY
FY 2019 BUDGET REQUEST TO CONGRESS
(Dollars in Millions)

	BIO	CISE	ENG	GEO	MPS	SBE	OISE	OPP	RRA	EHR	Total, NSF
Total, FY 2017 Actual	**$79.26**	**-**	**-**	**$130.00**	**$0.50**	**$17.98**	**-**	**$15.15**	**$242.89**	**-**	**$242.89**
Communication and Education	-	-	-	-	-	-	-	-	-	-	-
Integrated Modeling	-	-	-	22.00	0.50	3.50	-	3.28	29.28	-	29.28
Integrated Observations	50.26	-	-	20.00	-	-	-	5.00	75.26	-	75.26
Multidisciplinary Earth and Human System Understanding	29.00	-	-	82.00	-	5.73	-	6.87	123.60	-	123.60
Science of Adaptation and Science to Inform Adaptation Decisions	-	-	-	6.00	-	8.75	-	-	14.75	-	14.75
Delta from FY 2017 Actual to FY 2019 Request	**$10.74**	**-**	**-**	**-$10.00**	**-$0.50**	**-$4.80**	**-**	**-**	**-$4.56**	**-**	**-$4.56**
Communication and Education	-	-	-	-	-	-	-	-	-	-	-
Integrated Modeling	-	-	-	-2.00	-0.50	-	-	-	-2.50	-	-2.50
Integrated Observations	14.74	-	-	-	-	-	-	-	14.74	-	14.74
Multidisciplinary Earth and Human System Understanding	-4.00	-	-	-7.00	-	-2.00	-	-	-13.00	-	-13.00
Science of Adaptation and Science to Inform Adaptation Decisions	-	-	-	-1.00	-	-2.80	-	-	-3.80	-	-3.80
Total, FY 2019 Request	**$90.00**	**-**	**-**	**$120.00**	**-**	**$13.18**	**-**	**$15.15**	**$238.33**	**-**	**$238.33**
Communication and Education	-	-	-	-	-	-	-	-	-	-	-
Integrated Modeling	-	-	-	20.00	-	3.50	-	3.28	26.78	-	26.78
Integrated Observations	65.00	-	-	20.00	-	-	-	5.00	90.00	-	90.00
Multidisciplinary Earth and Human System Understanding	25.00	-	-	75.00	-	3.73	-	6.87	110.60	-	110.60
Science of Adaptation and Science to Inform Adaptation Decisions	-	-	-	5.00	-	5.95	-	-	10.95	-	10.95

NATIONAL SCIENCE FOUNDATION
PROGRAMS TO BROADEN PARTICIPATION
FY 2019 BUDGET REQUEST TO CONGRESS

(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	FY 2019 Request change over FY 2017 Actual Amount	FY 2019 Request change over FY 2017 Actual Percent
Total, NSF Broadening Participation Programs	**$926.52**	**-**	**$887.22**	**-$39.30**	**-4.2%**

Broadening participation infuses science and engineering excellence into varied individual, institutional, and geographic networks and provides for the discovery and nurturing of talent wherever it may be found. Additionally, NSF defines broadening participation in terms of individuals from underrepresented groups (i.e., women, underrepresented minorities, and persons with disabilities) as well as institutions (i.e., women's colleges, minority-serving institutions, and institutions primarily serving persons with disabilities) and geographic areas (i.e., rural, urban and EPSCoR jurisdictions) that do not participate in NSF research programs at rates comparable to others.[1]

NSF has taken a variety of approaches to broaden participation across its many programs. While broadening participation is included in the NSF review criteria, some program announcements and solicitations go beyond the standard criteria to include program-relevant suggestions and/or specific requirements for promoting diversity and inclusion. Investments range from capacity building, research centers, partnerships, and alliances to the use of co-funding or supplements to existing awards in the core research programs.

NSF's broadening participation portfolio can be divided into three categories: (1) Focused, (2) Emphases, and (3) Geographic Diversity. The following sections define each of these categories and provide a list of the programs and activities with their respective funding levels that comprise each.

[1]*Broadening Participation at the National Science Foundation: A Framework for Action*, www.nsf.gov/od/broadeningparticipation

Focused Programs

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

(Dollars in Millions)

	Amount of Funding Captured	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	FY 2019 Request change over FY 2017 Actual Amount	Percent
ADVANCE	100%	$18.00	-	$18.00	-	-
Alliances for Graduate Education & the Professoriate (AGEP)	100%	8.01	-	8.00	-0.01	-0.1%
AGEP Graduate Research Supplements (AGEP-GRS)	100%	2.42	-	2.51	0.09	3.6%
Broadening Participation in Biology Fellowships	100%	2.50	-	2.50	-	-
Broadening Participation in Engineering (BPE)	100%	9.40	-	7.85	-1.55	-16.5%
Career-Life Balance (CLB)	100%	0.65	-	0.32	-0.33	-50.5%
Centers of Research Excellence in Science & Technology (CREST)	100%	24.02	-	24.00	-0.02	-0.1%
Excellence Awards in Science & Engineering (EASE)[1]	100%	4.31	-	4.31	-	-
Historically Black Colleges & Universities Undergraduate Program (HBCU-UP)	100%	35.01	-	35.00	-0.01	-0.0%
HBCU Excellence in Research (HBCU-EiR)	100%	-	-	10.00	10.00	N/A
Improving Undergraduate STEM Education (IUSE): Hispanic Serving Institutions (HSI) program	100%	-	-	15.00	15.00	N/A
Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science (NSF INCLUDES)	100%	14.13	-	20.00	5.87	41.6%
Louis Stokes Alliances for Minority Participation (LSAMP)	100%	46.15	-	46.00	-0.15	-0.3%
Partnerships for Research & Education in Materials (PREM)	100%	6.13	-	6.30	0.17	2.8%
Partnerships in Astronomy & Astrophysics Research Education (PAARE)	100%	-	-	1.00	1.00	N/A
SBE Postdoctoral Research Fellowships-Broadening Participation	100%	1.54	-	1.50	-0.04	-2.5%
SBE Science of Broadening Participation	100%	1.50	-	1.50	-	-
Tribal Colleges & Universities Program (TCUP)	100%	14.01	-	14.00	-0.01	-0.1%
Subtotal, Focused Programs		**$187.77**	**-**	**$217.79**	**$30.02**	**16.0%**

[1]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).

Emphasis Programs

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 where an award:

- Was to a Minority Serving Institution (MSI);
- Had at least 50 percent of its principal investigators from an underrepresented group; or
- Had at least 50 percent of the students or postdocs supported by the grant reporting themselves as members of an underrepresented group on project reports.

(Dollars in Millions)

	Amount of Funding Captured	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	FY 2019 Request change over FY 2017 Actual Amount	Percent
Advancing Informal STEM Learning (AISL)	53%	$33.34	-	$33.13	-$0.21	-0.6%
Disability and Rehabilitation Engineering (DARE)	55%	2.56	-	2.48	-0.08	-3.2%
Discovery Research PreK-12 (DRK-12)	62%	50.97	-	50.97	-	-
Engineering Research Centers (ERC)	63%	36.22	-	35.28	-0.94	-2.6%
Graduate Research Fellowship Program (GRFP)	63%	201.27	-	170.55	-30.72	-15.3%
Improving Undergraduate STEM Education (IUSE)	56%	57.18	-	57.40	0.22	0.4%
Innovative Technology Experiences for Students and Teachers (ITEST)[2]	51%	17.90	-	12.75	-5.15	-28.8%
International Research Experiences for Students (IRES)	53%	3.70	-	6.36	2.66	71.9%
NSF Scholarships in STEM (S-STEM)[2]	59%	49.78	-	44.25	-5.53	-11.1%
Research Experiences for Undergraduates (REU) - Sites and Supplements	55%	51.84	-	44.02	-7.82	-15.1%
Robert Noyce Teacher Scholarship Program (NOYCE)	61%	37.57	-	28.67	-8.90	-23.7%
STEM + Computing Partnerships (STEM+C Partnerships)	52%	33.62	-	23.57	-10.05	-29.9%
Subtotal, Emphasis Programs		**$575.95**	**-**	**$509.43**	**-$66.52**	**-11.5%**

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

Geographic Diversity Programs

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

(Dollars in Millions)

	Amount of Funding Captured	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	FY 2019 Request change over FY 2017 Actual Amount	FY 2019 Request change over FY 2017 Actual Percent
EPSCoR	100%	$162.80	-	$160.00	-$2.80	-1.7%
Subtotal, Geographic Diversity Programs		**$162.80**	**-**	**$160.00**	**-$2.80**	**-1.7%**

NATIONAL SCIENCE FOUNDATION
CoSTEM INVENTORY AND POSTDOCTORAL FELLOWSHIP PROGRAMS
BY LEVEL OF EDUCATION
FY 2019 BUDGET REQUEST TO CONGRESS
(Dollars in Millions)

		FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	FY 2019 Request change over FY 2017 Actual Amount	Percent
Minority-Serving Institutions		**$49.02**	**-**	**$49.00**	**-$0.02**	**-0.0%**
UG	Historically Black Colleges and Universities Undergraduate Program (HBCU-UP)	35.01	-	35.00	-0.01	-0.0%
UG	Tribal Colleges and Universities Program (TCUP)	14.01	-	14.00	-0.01	-0.1%
Fellowships and Scholarships		**$574.23**	**-**	**$499.86**	**-$74.37**	**-13.0%**
UG	NSF Scholarships in STEM (S-STEM) (H-1B)	84.38	-	75.00	-9.38	-11.1%
UG	Robert Noyce Scholarship (Noyce) Program	61.59	-	47.00	-14.59	-23.7%
G	Cybercorps®: Scholarship for Service (SFS)	54.95	-	55.00	0.05	0.1%
G	East Asia and Pacific Summer Institutes for U.S. Grad Students (EAPSI)[1]	0.96	-	-	-0.96	-100.0%
G	Graduate Research Fellowship (GRFP)	319.48	-	270.72	-48.76	-15.3%
G	NSF Research Traineeship (NRT)	52.86	-	52.14	-0.72	-1.4%
Other Grant Programs		**$599.63**	**-**	**$565.40**	**-$34.23**	**-5.7%**
K-12	Discovery Research PreK-12 (DRK-12)	82.21	-	82.21	-	-
K-12	Innovative Technology Experiences for Teachers and Students (ITEST) (H1-B)	35.10	-	25.00	-10.10	-28.8%
K-12	STEM + Computing (STEM + C) Partnerships	64.38	-	45.14	-19.24	-29.9%
UG	Advanced Technological Education (ATE)	65.91	-	66.00	0.09	0.1%
UG	Emerging Frontiers in Research and Innovation (EFRI) Research Experience and Mentoring (REM)	0.68	-	0.80	0.12	16.9%
UG	Improving Undergraduate STEM Education (IUSE)	102.10	-	102.50	0.40	0.4%
UG	International Research Experiences for Students (IRES)	6.98	-	12.00	5.02	71.9%
UG	Louis Stokes Alliances for Minority Participation (LSAMP)	46.15	-	46.00	-0.15	-0.3%
UG	Research Experiences for Undergraduates (REU) - Sites and Supplements	94.26	-	80.04	-14.22	-15.1%
UG	Research Experiences for Teachers (RET) in Engineering and Computer Science	7.67	-	6.05	-1.62	-21.1%
G	Alliances for Graduate Education and the Professoriate (AGEP)	8.01	-	8.00	-0.01	-0.1%
G	Training-based Workforce Development for Advanced Cyberinfrastructure (CyberTraining)	4.84	-	4.85	0.01	0.1%
O&I	Advancing Informal STEM Learning (AISL)	62.90	-	62.50	-0.40	-0.6%
O&I	Excellence Awards in Science and Engineering (EASE)	4.31	-	4.31	0.00	0.0%
O&I	Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science (NSF INCLUDES)	14.13	-	20.00	5.87	41.6%
Subtotal, Above Categories (CoSTEM Inventory		**$1,222.89**	**-**	**$1,114.26**	**-$108.63**	**-8.9%**
G	**NSF Postdoctoral Programs**	**$25.13**	**-**	**$20.99**	**-$4.14**	**-16.5%**
	Astronomy and Astrophysics Postdoctoral Fellowships (AAPF)	2.50	-	2.50	-	-
	Geosciences Postdoctoral Fellowships	3.43	-	3.49	0.06	1.7%
	International Research Fellowship Program[2]	1.22	-	-	-1.22	-100.0%
	Mathematical Sciences Postdoctoral Research Fellowships (MSPRF)	6.45	-	6.00	-0.45	-7.0%
	Postdoctoral Research Fellowships in Biology (PRFB)	7.82	-	6.00	-1.82	-23.3%
	SPRF-Broadening Participation	2.17	-	1.50	-0.67	-30.9%
	SPRF-Fundamental Research	1.54	-	1.50	-0.04	-2.6%

NATIONAL SCIENCE FOUNDATION
CoSTEM INVENTORY AND POSTDOCTORAL FELLOWSHIP PROGRAMS
BY LEVEL OF EDUCATION
FY 2019 BUDGET REQUEST TO CONGRESS
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	FY 2019 Request change over FY 2017 Actual Amount	FY 2019 Request change over FY 2017 Actual Percent
K-12 STEM Education Programs (K-12) Subtotal	**$181.69**	**-**	**$152.35**	**-$29.34**	**-16.2%**
Undergraduate STEM Education Programs (UG) Subtotal	**$518.75**	**-**	**$484.39**	**-$34.36**	**-6.6%**
Graduate and Professional STEM Education Programs (G) Subtotal	**$466.24**	**-**	**$411.70**	**-$54.54**	**-11.7%**
Outreach and Informal STEM Education Programs (O&I) Subtotal	**$81.34**	**-**	**$86.81**	**$5.47**	**6.7%**
Total, NSF STEM Education	**$1,248.02**	**-**	**$1,135.25**	**-$112.77**	**-9.0%**

[1]In FY 2019, the East Asia-Pacific Summer Institute (EAPSI) program will be terminated.
[2]In FY 2018, the International Research Fellowship program was terminated.

NATIONAL SCIENCE FOUNDATION
EDUCATION AND HUMAN RESOURCES FUNDING BY DIVISION AND PROGRAM
FY 2019 BUDGET REQUEST TO CONGRESS
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	FY 2019 Request change over FY 2017 Actual Amount	Percent
Division of Research on Learning in Formal and Informal Settings (DRL)	**$222.62**	**-**	**$202.98**	**-$19.64**	**-8.8%**
Learning and Learning Environments	**25.63**	**-**	**25.63**	**-**	**-**
EHR Core Research (ECR): STEM Learning	25.63	-	25.63	-	-
Broadening Participation and Institutional Capacity	**145.11**	**-**	**144.71**	**-0.40**	**-0.3%**
Advancing Informal STEM Learning (AISL)	62.90	-	62.50	-0.40	-0.6%
Discovery Research PreK-12 (DRK-12)	82.21	-	82.21	-	-
STEM Professional Workforce	**51.88**	**-**	**32.64**	**-19.24**	**-37.1%**
Science, Technology, Engineering, and Mathematics + Computing (STEM + C) Partnerships[1]	51.88	-	32.64	-19.24	-37.1%
Division of Graduate Education (DGE)	**$272.11**	**-**	**$258.55**	**-$13.56**	**-5.0%**
Learning and Learning Environments	**11.51**	**-**	**11.03**	**-0.48**	**-4.2%**
Project and Program Evaluation (PPE)	11.51	-	11.03	-0.48	-4.2%
STEM Professional Workforce	**260.60**	**-**	**247.52**	**-13.08**	**-5.0%**
EHR Core Research (ECR): STEM Professional Workforce Preparation	15.98	-	15.97	-0.01	-0.1%
Cybercorps®: Scholarship for Service (SFS)	54.95	-	55.00	0.05	0.1%
Graduate Research Fellowship Program (GRFP)	158.70	-	135.36	-23.34	-14.7%
NSF Research Traineeship (NRT)	30.97	-	41.19	10.22	33.0%
Division of Human Resource Development (HRD)	**$149.50**	**-**	**$187.19**	**$37.69**	**25.2%**
Learning and Learning Environments	**58.56**	**-**	**75.00**	**16.44**	**28.1%**
ADVANCE	1.53	-	18.00	16.47	1076.5%
Alliances for Graduate Education and the Professoriate (AGEP)	8.01	-	8.00	-0.01	-0.1%
Historically Black Colleges and Universities Undergraduate Program (HBCU-UP)	35.01	-	35.00	-0.01	-0.0%
Tribal Colleges and Universities Program (TCUP)	14.01	-	14.00	-0.01	-0.1%
Broadening Participation and Institutional Capacity	**62.61**	**-**	**83.88**	**21.27**	**34.0%**
EHR Core Research (ECR): Broadening Participation and Institutional Capacity in STEM	12.88	-	12.88	0.00	-
IUSE: Hispanic Serving Institutions (HSI) Program	-	-	5.00	5.00	N/A
NSF INCLUDES	3.58	-	20.00	16.42	458.7%
Louis Stokes Alliances for Minority Participation (LSAMP)	46.15	-	46.00	-0.15	-0.3%
STEM Professional Workforce	**28.33**	**-**	**28.31**	**-0.02**	**-0.1%**
Centers for Research Excellence in Science and Technology (CREST)	24.02	-	24.00	-0.02	-0.1%
Excellence Awards in Science and Engineering (EASE)	4.31	-	4.31	-	-
Division of Undergraduate Education (DUE)	**$229.14**	**-**	**$224.65**	**-$4.49**	**-2.0%**
Learning and Learning Environments	**100.12**	**-**	**110.10**	**9.98**	**10.0%**
EHR Core Research (ECR): STEM Learning Environments	13.11	-	13.10	-0.01	-0.1%
Improving Undergraduate STEM Education (IUSE)	87.01	-	87.00	-0.01	-0.0%
IUSE: Hispanic Serving Institutions (HSI) Program	-	-	10.00	10.00	N/A
STEM Professional Workforce	**129.02**	**-**	**114.55**	**-14.47**	**-11.2%**
Advanced Technological Education (ATE)	65.91	-	66.00	0.09	0.1%
NSF Innovation Corps (I-Corps™)	1.52	-	1.55	0.03	2.0%
Robert Noyce Teacher Scholarship Program (Noyce)	61.59	-	47.00	-14.59	-23.7%
Total, EHR	**$873.37**	**-**	**$873.37**	**-**	**-**
Total, Learning and Learning Environments	**$195.82**	**-**	**$221.76**	**$25.94**	**13.2%**
Total, Broadening Participation and Institutional Capacity	**$207.72**	**-**	**$228.59**	**$20.87**	**10.0%**
Total, STEM Professional Workforce	**$469.83**	**-**	**$423.02**	**-$46.81**	**-10.0%**

[1]The STEM+C program will not run a new competition in FY 2019. However, it will provide co-funding to other programs supporting research on computer science education, including partnering with CISE on the Computer Science for All: Research Practitioner Partnerships (CS for ALL: RPP) program. Other EHR programs (DRK-12, AISL, and ECR: STEM Learning) will expand their portfolios to further support research addressing computer science teaching and learning, including research on computational thinking and the integration of computing with other STEM disciplines.

NATIONAL SCIENCE FOUNDATION
RESEARCH INFRASTRUCTURE (RI) FUNDING, BY ACCOUNT AND ACTIVITY
FY 2019 BUDGET REQUEST TO CONGRESS
(Dollars in Millions)

	FY 2017 Actual	FY 2017 Actual RI Funding	FY 2018 (TBD)	FY 2018 (TBD) RI Funding	FY 2019 Request	FY 2019 Request RI Funding	FY 2019 Request RI change over FY 2017 Actual RI Amount	FY 2019 Request RI change over FY 2017 Actual RI Percent
BIO	$742.22	$122.99	-	-	$738.16	$119.36	-$3.63	-3.0%
CISE	935.93	168.54	-	-	925.42	161.85	-6.69	-4.0%
ENG	930.92	30.91	-	-	921.43	22.58	-8.33	-26.9%
GEO	825.62	330.10	-	-	852.98	349.12	19.02	5.8%
MPS	1,362.43	352.56	-	-	1,345.32	346.17	-6.39	-1.8%
SBE	270.89	61.09	-	-	246.19	58.04	-3.05	-5.0%
OISE	48.96	0.10	-	-	48.50	0.10	-	-
OPP	467.85	346.34	-	-	534.54	420.19	73.85	21.3%
IA	420.27	79.93	-	-	536.72	137.85	57.92	72.5%
U.S. Arctic Research Commission	1.43	-	-	-	1.42	-	-	N/A
Research & Related Activities	$6,006.51	$1,492.57	-	-	$6,150.68	$1,615.26	$122.69	8.2%
Education & Human Resources	$873.37	-	-	-	$873.37	-	-	N/A
Major Research Equipment & Facilities Construction	$222.78	$222.45	-	-	$94.65	$93.65	-$128.80	-57.9%
Agency Operations & Award Management	$382.06	-	-	-	$333.63	-	-	N/A
National Science Board	$4.27	-	-	-	$4.32	-	-	N/A
Office of Inspector General	$15.10	-	-	-	$15.35	-	-	N/A
Total, National Science Foundation	**$7,504.10**	**$1,715.02**	**-**	**-**	**$7,472.00**	**$1,708.91**	**-$6.11**	**-0.4%**

NATIONAL SCIENCE FOUNDATION
RESEARCH INFRASTRUCTURE SUMMARY
FY 2019 BUDGET REQUEST TO CONGRESS
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	FY 2019 Request change over FY 2017 Actual Amount	Percent
Facilities	**$703.76**	**-**	**$707.65**	**$3.89**	**0.6%**
Academic Research Fleet[1]	82.03	-	77.80	-4.23	-5.2%
Arecibo Observatory	8.00	-	6.08	-1.92	-24.0%
AST Portfolio Review Implementation[2]	0.09	-	6.74	6.65	7058.4%
Cornell High Energy Synchrotron Source (CHESS)	26.20	-	10.00	-16.20	-61.8%
Gemini Observatory	24.24	-	21.66	-2.58	-10.6%
Geodesy Advancing Geosciences and EarthScope (GAGE)	13.10	-	12.19	-0.91	-6.9%
IceCube Neutrino Observatory (IceCube)	7.00	-	7.00	-	-
International Ocean Discovery Program (IODP)	48.00	-	48.00	-	-
Large Hadron Collider (LHC)	16.00	-	16.00	-	-
Laser-Interferometer Gravitational-wave Observatory (LIGO)	41.93	-	45.00	3.07	7.3%
National High-Magnetic Field Laboratory (NHMFL)	23.15	-	35.76	12.61	54.5%
National Nanotechnology Coordinated Infrastructure (NNCI)	15.55	-	14.78	-0.77	-5.0%
National Superconducting Cyclotron Laboratory (NSCL) (MSU Cyclotron)	24.00	-	24.00	-	-
Natural Hazards Engineering Research Infrastructure (NHERI)	14.99	-	11.75	-3.24	-21.6%
Ocean Observatories Initiative (OOI)[3]	0.34	-	40.00	39.66	11638.8%
Other Facilities[4]	2.78	-	2.79	0.01	0.2%
Polar Facilities and Logistics	330.30	-	303.94	-26.36	-8.0%
Seismological Facilities for Advancement of Geosciences and EarthScope (SAGE)	26.05	-	24.16	-1.89	-7.3%
Major Research Facilities Construction Investments	**$297.01**	**-**	**$288.02**	**-$8.99**	**-3.0%**
Construction, Acquisition, and Commissioning (MREFC)[5]	222.45	-	93.65	-128.80	-57.9%
Construction, Acquisition, and Commissioning (R&RA)[6]	-	-	103.70	103.70	N/A
Development and Design[7]	10.79	-	6.67	-4.12	-38.2%
Initial Operations and Maintenance During Construction[8]	63.76	-	84.00	20.24	31.7%
Federally Funded R&D Centers	**$221.54**	**-**	**$214.55**	**-$6.99**	**-3.2%**
National Center for Atmospheric Research (NCAR)	99.70	-	94.70	-5.00	-5.0%
National Optical Astronomy Observatories (NOAO)	22.99	-	20.13	-2.86	-12.4%
National Radio Astronomy Observatories (NRAO)[9]	76.66	-	79.13	2.47	3.2%
Other Astronomical Facilities[10]	11.45	-	11.85	0.40	3.5%
National Solar Observatory[11]	6.00	-	4.00	-2.00	-33.3%
Science & Technology Policy Institute (STPI)	4.74	-	4.74	-	-
Other Research Instrumentation and Infrastructure	**$493.72**	**-**	**$500.58**	**$6.86**	**1.4%**
Major Research Instrumentation (MRI)	76.20	-	75.00	-1.20	-1.6%
Mid-scale Research Infrastructure	39.38	-	75.31	35.93	91.2%
National Center for Science & Engineering Statistics (NCSES)	45.15	-	50.55	5.40	12.0%
NCSES Science of Science and Innovation Policy (SciSIP) Activities	4.95	-	-	-4.95	-100.0%
Networking and Computational Resources Infrastructure and Services	128.15	-	117.50	-10.65	-8.3%
Polar Environment, Health, and Safety (PEHS)	6.61	-	6.13	-0.48	-7.2%
Research Resources[12]	193.29	-	174.34	-18.95	-9.8%
Research Resources – Public Access Initiative	-	-	1.75	1.75	N/A
Subtotal, Research Infrastructure Support	**$1,716.02**	**-**	**$1,710.80**	**-$5.22**	**-0.3%**
Research Infrastructure Stewardship Offset	**-$1.00**	**-**	**-$1.89**	**-$0.89**	**89.1%**
RESEARCH INFRASTRUCTURE TOTAL	**$1,715.02**	**-**	**$1,708.91**	**-$6.11**	**-0.4%**

NATIONAL SCIENCE FOUNDATION
RESEARCH INFRASTRUCTURE SUMMARY
FY 2019 BUDGET REQUEST TO CONGRESS

[1]Academic Research Fleet funding includes ship operations and upgrades. Regional Class Research Vessels (RCRV) funding is no longer included on this line as MREFC construction began in FY 2017.

[2]The funding change for AST Portfolio Review is due to the timing of contracts engaged to meet legal requirements of portfolio review activities (e.g., National Historic Preservation Act, National Environmental Policy Act).

[3]The FY 2017 budget of $340,000 reflects only the incremental support necessary to enable the potential transition of managing institutions associated with the competition for a new operation and management award of the OOI. FY 2017 operations and maintenance were funded in a prior year.

[4]Other Facilities includes ongoing MPS support for the Center for High Resolution Neutron Scattering (CHRNS).

[5] Construction, Acquisition, and Commissioning are for implementation support provided through the MREFC account. MREFC funding is included for NEON and RCRV in FY 2017; in FY 2017 and FY 2019, DKIST, and LSST are included.

[6]Construction, Acquisition, and Commissioning are for implementation support provided through the R&RA account. R&RA funding is included for AIMS in FY 2019.

[7]Development and Design includes funding for potential next generation multi-user facilities. This line reflects funding for RCRV in FY 2017 ($2.11 million) and Antarctic Infrastructure Modernization for Science (AIMS) in FY 2017 and FY 2019 ($2.97 million and $370,000, respectively). Also included is funding for a potential High-Lumosity Large Hadron Collider (LHL-HC) Upgrade in FY 2017 and FY 2019 ($5.71 million and $6.30 million, respectively).

[8]Initial Operations and Maintenance During Construction are Research and Related Activities (R&RA) funds for these purposes while MREFC construction is ongoing. Funding is included for FY 2017 and FY 2019 for NEON ($50.26 million and $52.0 million, respectively) and DKIST ($13.50 million and $18.50 million, respectively), and for LSST in FY 2019 ($500,000).

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

[10]Other AST Facilities: This section captures funding for the Green Bank Observatory and the Long Baseline Observatory (formerly VLBA). Support beyond FY 2018 is currently undecided, so funding for FY 2019 is notional.

[11]National Solar Observatory (NSO) totals presented do not include $11.50 million in FY 2017 and $16.50 in FY 2019 for operations and maintenance support for the DKIST facility construction project. DKIST funding is captured within the total presented on the Initial Operations and Maintenance During Construction line.

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

NSF AUTHORIZATIONS

NATIONAL SCIENCE FOUNDATION CURRENT AUTHORIZATIONS

(Dollars in Millions)

LEGISLATION	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Authorization Levels FY 2017	FY 2018	FY 2019
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*		
International Cooperation and Coordination with Foreign Policy				*within the limit of appropriated funds*		
Contract Arrangements				*utilize appropriations available*		
American Innovation and Competitiveness Act P.L. 114-329 (Does not authorize appropriations)						
The American Innovation and Competitiveness Act authorizes NSF's research and education programs. The law also promotes NSF's commitment to diversity in STEM fields, and incentivizes NSF programs which encourage private-sector involvement, while re-affirming NSF's continued commitment to entrepreneurship and commercialization.						
SBIR and STTR reauthorized through 2022 at current levels under the National Defense Authorization Act of Fiscal Year 2017, P.L. 114-328						
Small Business Innovation Research (SBIR) Program[2]	**$174.36**	**-**	**$174.09**	*3.2% of research funds in 2017, 2018, and 2019*		
Small Business Technology Transfer (STTR) Program[2]	**$24.69**	**-**	**$24.48**	*0.45% of research funds in 2017, 2018 and 2019*		
National Windstorm Impact Reduction Act Reauthorization of 2015, P.L. 114-52[3]	**$47.02**			*$9.68*		
Engineering and the atmospheric sciences to improve the understanding of the behavior of windstorms and their impact on buildings, structures, and lifelines; and Economic and social factors influencing windstorm risk reduction measures.						
The Research Excellence and Advancements for Dyslexia Act (READ Act), P.L. 114-124	**$11.76**	*****	*****	*$5.00*	*$5.00*	*$5.00*
The National Science Foundation shall support multi-directorate, merit-reviewed, and competitively awarded research on the science of specific learning disability, including dyslexia, such as research on the early identification of children and students with dyslexia, professional development for teachers and administrators of students with dyslexia, curricula and educational tools needed for children with dyslexia, and implementation and scaling of successful models of dyslexia intervention.[4]						

[1] Organic legislation establishing NSF.

[2] SBIR and STTR are reauthorized through September 30, 2022.

[3] Actual amounts will be reported after awards are completed.

[4] The $5.0 million shall include not less than $2.5 million for research on the science of dyslexia, for each of fiscal years 2017 through 2021. FY 2017 Actuals funding includes $6.57 million for dyslexia research.

NATIONAL SCIENCE FOUNDATION (NSF)
COMPUTER SCIENCE EDUCATION RESEARCH CONGRESSIONAL REPORT
IN COMPLIANCE WITH PUBLIC LAW 114-329:
AMERICAN INNOVATION AND COMPETITIVENESS ACT, SEC. 310 (E)

Summary

The American Innovation and Competitiveness Act, 2017, Public Law 114-329, requires the National Science Foundation (NSF) to undertake specific activities regarding computer science education research (Sec. 310):

"(b) GRANT PROGRAM.-

(1) IN GENERAL. — The Director of the Foundation shall award grants to eligible entities to research computer science education and computational thinking.

(2) RESEARCH. — The research described in paragraph (1) may include the development or adaptation, piloting or full implementation, and testing of —

A. models of preservice preparation for teachers who will teach computer science and computational thinking;
B. scalable and sustainable models of professional development and ongoing support for the teachers described in subparagraph (A);
C. tools and models for teaching and learning aimed at supporting student success and inclusion in computing within and across diverse populations, particularly poor, rural, and tribal populations and other populations that have been historically underrepresented in computer science and STEM fields; and
D. high-quality learning opportunities for teaching computer science and, especially in poor, rural, or tribal schools at the elementary school and middle school levels, for integrating computational thinking into STEM teaching and learning.

(c) COLLABORATIONS. — In carrying out the grants established in subsection (b), eligible entities may collaborate and partner with local or remote schools to support the integration of computing and computational thinking within pre-kindergarten through grade 12 STEM curricula and instruction.

(d) METRICS. — The Director of the Foundation shall develop metrics to measure the success of the grant program funded under this section in achieving program goals.

(e) REPORT. — The Director of the Foundation shall report, in the annual budget submission to Congress, on the success of the program as measured by the metrics in subsection (d).

(f) DEFINITION OF ELIGIBLE ENTITY. — In this section, the term "eligible entity" means an institution of higher education or a non-profit research organization."

Background

The Computer Science for All: Researcher Practitioner Partnerships (CSforAll: RPP) program began with solicitation NSF 17-525.[1] The CSforAll: RPP program synopsis in the program solicitation states that:

[1] www.nsf.gov/pubs/2017/nsf17525/nsf17525.htm

"This program aims to provide all U.S. students the opportunity to participate in computer science (CS) and computational thinking (CT) education in their schools at the K-12 levels. With this solicitation, the National Science Foundation (NSF) focuses on researcher-practitioner partnerships (RPPs) that foster the research and development needed to bring CS/CT to all schools. Specifically, this solicitation aims to provide high school teachers with the preparation, professional development and ongoing support that they need to teach rigorous computer science courses, and K-8 teachers with the instructional materials and preparation they need to integrate CS/CT into their teaching."

Metrics

The program's first deadline for proposals was February 28, 2017. NSF convened merit review panels in April 2017, and the program made its first cohort of 34 two- to four-year awards by the end of FY 2017. Short-, mid-, and longer-term metrics for success were developed and reported upon, as follows:

- Short-term metrics will focus on ensuring that the program is making awards in the four areas outlined in the law and that the awards address the goal of broadening participation in computer science. One indicator of broadening participation is the diversity of the populations targeted in the awards.
- Mid-term metrics will include the extent to which funded projects are achieving goals as measured by the progress reported in NSF's required annual and final project reports.
- Longer-term (beyond five years) metrics will include an evaluation of the outcomes of the program, which are based on the program aims as described in the program solicitation and the well-aligned requirements of Public Law 114-329. Program staff are working with the Evaluation and Monitoring Group in the NSF Directorate for Education and Human Resources and the Evaluation and Assessment Capability within the NSF Office of Integrative Activities to develop (1) a set of specific longer-term metrics and (2) a program evaluation plan for measuring the collective success of the CSforAll: RPP projects on these longer-term metrics.

<u>Report on the Success of the Program as Measured by the Short-Term Metrics</u>
Below is a summary of the CSforAll: RPP projects that were funded in FY 2017 pursuant to NSF 17-525:

- 15 awards address subsection (b)(2) A and (b)(2) B; and
- 13 awards address subsection (b)(2) C.

In addition, the program also supported four awards for conferences (workshops), and two awards for backbone organizations.

Finally, all awards except those supporting backbone organizations identified at least one underrepresented or underserved group, as outlined in the table below, to address subsection (b)(2) D. (Note: some awards serve more than one underrepresented group and thus the numbers of awards in the table below total to more than 34.)

Underrepresented or Underserved Group Served by Backbone Organizations

Category	Groups Served
Rural	12
Low Socio-Economic Status	8
Disabilities	4
Pacific Islanders	1
Women/Girls	10
English Language Learners	2
African-Americans	10
Native Americans	4
Latino/a	17

NATIONAL SCIENCE FOUNDATION (NSF)
ESTABLISHED PROGRAM TO STIMULATE COMPETITIVE RESEARCH (EPSCOR)
CONGRESSIONAL REPORT IN COMPLIANCE WITH PUBLIC LAW 114-329: AMERICAN INNOVATION AND COMPETITIVENESS ACT, SEC. 103 (D) (1-3)
FISCAL YEAR 2017

This report summarizes fiscal year (FY) 2017 NSF funding to institutions and entities in EPSCoR jurisdictions, as required by the American Innovation and Competitiveness Act Sec. 103(d)(1-3). Specifically, the report itemizes

(1) a description of the program strategy and objectives;
(2) a description of the awards made in the previous fiscal year including
  (A) the total amount made available, by state, under EPSCoR;
  (B) the total amount of agency funding made available to all institutions and entities within each EPSCoR state;
  (C) the efforts and accomplishments to more fully integrate the EPSCoR states in major agency activities and initiatives;
  (D) the percentage of EPSCoR reviewers from EPSCoR states;
  (E) the number of programs or large collaborator awards involving a partnership of organizations and institutions from EPSCoR and non-EPSCoR states; and
(3) an analysis of the gains in academic research quality and competitiveness, and in science and technology human resource development, achieved by the program over the last 5 years.

Introduction

EPSCoR utilizes three investment strategies in pursuit of its goal to strengthen research capacity and competitiveness in eligible jurisdictions. These investment strategies are: (1) Research Infrastructure Improvement (RII) awards that support physical, human, and cyberinfrastructure development; (2) Co-Funding in partnership with NSF directorates and offices that support individual investigators and groups within EPSCoR jurisdictions; and (3) Outreach activities and workshops that bring EPSCoR jurisdiction investigators together with program staff from across the Foundation to explore opportunities in emerging areas of science and engineering aligned with NSF strategic priorities and with jurisdictional science and technology goals.

EPSCoR Strategies and Objectives (Sec. 103(d)(1)).

EPSCoR's strategies and objectives in FY 2017 remained the same as those described in the FY 2016 report. Specifically, the mission of EPSCoR is "to advance excellence in science and engineering research and education in order to achieve sustainable increases in research, education, and training capacity and competitiveness that will enable EPSCoR jurisdictions to have increased engagement in areas supported by the NSF." Thus, EPSCoR's goals are:

- To catalyze the development of research capabilities and the creation of new knowledge that expands jurisdictions' contributions to scientific discovery, innovation, learning, and knowledge-based prosperity.
- To establish sustainable Science, Technology, Engineering and Math (STEM) education, training, and professional development pathways that advance jurisdiction-identified research areas, NSF focus areas, and workforce development.
- To broaden direct participation of diverse individuals, institutions, and organizations in the project's science and engineering research and education initiatives.
- To effect sustainable engagement of project participants and partners, the jurisdiction, the national research community, and the general public through data-sharing, communication, outreach, and

dissemination.

- To impact research, education, and economic development beyond the project at academic, government, and private sector levels.

NSF Funding Made Available, by jurisdiction, under EPSCoR (Sec. 103(d)(2)(A)).

In FY 2017, NSF EPSCoR invested a total of $162.80 million in support of its programmatic activities. Of this, $135.75 million (83.4 percent) was directed to RII, $24.92 million (15.3 percent) to co-funding, and $2.13 million (1.3 percent) to outreach activities and workshops. The table below details the investments from EPSCoR resources, and EPSCoR investments in co-funding actions.

FY 2017 EPSCoR Funding by Jurisdiction
(Dollars in Millions)

EPSCoR Jurisdiction	RII program	Outreach & Workshops[1]	EPSCoR Co-funding	EPSCoR Total
AK	$1.22	$2.05	$0.84	$4.11
AL	4.33	-	0.92	5.25
AR	0.27	-	1.16	1.43
DE	3.26	-	0.25	3.51
GU	1.94	-	-	1.94
HI	3.77	0.02	1.00	4.79
ID	7.32	-	0.63	7.95
KS	6.03	-	2.18	8.21
KY	4.21	-	1.11	5.32
LA	4.27	-	1.90	6.17
ME	5.00	-	0.90	5.90
MO	8.00	-	0.70	8.70
MS	1.82	-	0.66	2.48
MT	4.43	-	0.93	5.36
ND	0.19	-	0.57	0.76
NE	8.28	-	1.48	9.76
NH	5.05	-	0.85	5.90
NM	7.11	0.02	2.34	9.47
NV	4.16	-	0.70	4.86
OK	7.00	-	1.01	8.01
PR	2.00	-	0.05	2.05
RI	9.82	-	0.30	10.12
SC	11.54	-	2.24	13.78
SD	7.31	0.02	0.79	8.12
VI	3.62	-	-	3.62
VT	4.25	-	0.15	4.40
WV	4.16	-	0.95	5.11
WY	2.17	-	-	2.17
Admin	3.22	0.02	0.31	3.55
Total	**$135.75**	**$2.13**	**$24.92**	**$162.80**

[1] Tier II Communications workshop to HI, NM, and SD totaled $56,045. Divided evenly by 3.

Total NSF Funding Made Available in all EPSCoR Jurisdictions (Sec. 103 (d)(2)(B)).

In FY 2017, NSF invested a total of $862.63 million in support of EPSCoR jurisdictions. The table below details NSF investments in EPSCoR jurisdictions including research support funding, education and human resources, and major research equipment.

FY 2017 NSF Funding
Made Available to All EPSCoR Jurisdictions
(Dollars in Millions)

EPSCoR Jurisdiction	NSF Funding
AK	$46.33
AL	51.16
AR	15.41
DE	25.20
GU	2.50
HI	45.17
ID	24.70
KS	41.60
KY	30.05
LA	36.92
ME	22.31
MO	68.07
MS	20.95
MT	31.78
ND	13.43
NE	37.93
NH	40.04
NM	51.70
NV	18.38
OK	40.47
PR	10.29
RI	49.39
SC	75.56
SD	14.82
VI	5.11
VT	15.67
WV	14.35
WY	13.34
Total	**$862.63**

Integration of EPSCoR Jurisdictions in Major Activities and Initiatives of the Foundation (Sec. 103 (d)(2)(C)).

All EPSCoR programmatic activities target integration and assimilation of EPSCoR jurisdictions into the research and education programs of the Foundation's disciplinary directorates. RII awards promote the coordination and integration of recipient jurisdictions into major NSF programmatic activities. Additionally, EPSCoR consults and engages NSF disciplinary program officers (POs) in merit review processes and post-award evaluations, such as site visits and reverse site visits (RSVs). Site visits and RSVs are intended to provide additional project oversight by allowing jurisdictions to report on the progress of their RII projects in relation to their stated goals and the programmatic terms and conditions. Disciplinary

POs assist in the identification of reviewers, serve as site visit and RSV observers, and provide knowledge about the ongoing activities within the directorate that could be leveraged to sustain RII efforts after the performance period of the EPSCoR award.

National, regional, and jurisdictional meetings of the EPSCoR community facilitate interactions with NSF leadership to learn about the Foundation's strategic priorities and funding opportunities. Participation by EPSCoR researchers and educators in the merit review process across all disciplinary domains of the Foundation, in Committees of Visitors (COV) activities, in external advisory (Federal Advisory Committee Act) committees, and in disciplinary workshops that shape new activities is also vital to this integration.

Outreach to EPSCoR jurisdictions by NSF staff promotes integration of the EPSCoR community into mainstream NSF programs, as does co-funding of awards with the disciplinary programs of the Foundation. There is also an effort to promote in-reach, whereby EPSCoR facilitates opportunities for researchers and educators from EPSCoR jurisdictions to meet with NSF staff at the Foundation's headquarters. In these meetings, the EPSCoR participants are provided with information on NSF strategic priorities and funding opportunities. In FY 2017, EPSCoR staff facilitated approximately 24 in-reach meetings.

In FY 2017, EPSCoR staff promoted engagement of the EPSCoR community in NSF and other national activities. Examples are:

- Maintained efforts to better communicate the EPSCoR success story by continuing its communication workshop, Becoming an EPSCoR Champion, which targets RII Track-1 researchers and encourages them to specifically emphasize successful outcomes of their EPSCoR research. This workshop series helps researchers cultivate communication skills through disciplined, systematic messaging to convey an influential, economically-framed message that effectively signals the value of EPSCoR's activities. It seeks to enhance abilities to deliver the jurisdiction's scientific messages effectively, charismatically, and successfully.
- Encouraged EPSCoR-supported faculty to participate in NSF committee and review panels across NSF (e.g., COVs, site visits, and merit review panels).
- Continued the RII Track-2: Focused EPSCoR Collaborations (RII Track-2 FEC) solicitation. RII Track-2 FEC builds interjurisdictional collaborative teams of EPSCoR investigators in scientific focus areas consistent with NSF priorities. In addition, these awards have a particular focus on the development of early career/junior faculty. In FY 2017, proposals were invited on the topic of understanding the relationship between genome and phenome, aligned with the NSF Big Idea of Understanding the Rules of Life, and eight awards were made.
- Launched a new solicitation track, RII Track-4 EPSCoR Research Fellows, which provides opportunities for early career researchers to further develop their individual research potential through extended collaborative visits to the Nation's premier private, governmental, or academic research centers. Proposals in all areas of science and engineering supported by NSF were invited and 30 awards were made.

EPSCoR Reviewers (Sec. 103(d)(2)(D)).

Demographics of all reviewers who evaluated EPSCoR proposals or the program in FY 2017 are as follows: of the 150 reviewers, 21 percent were underrepresented minorities, 41 percent were female, 15 percent were from EPSCoR jurisdictions, 28 percent were new reviewers for NSF, and three percent were new reviewers from EPSCoR jurisdictions.

EPSCoR Collaborations and Partnerships (Sec. 103(d)(2)(E)).

All RII awards involve collaborations among scientists and engineers in EPSCoR jurisdictions. Additionally, RII awards require institutional collaborations, which are defined as collaborations between researchers at a RII awardee or sub-awardee and those at institutions not receiving any RII funds.

In FY 2017, there were 780 institutional collaborations within EPSCoR jurisdictions; 597 institutional collaborations between EPSCoR jurisdictions and other EPSCoR and non-EPSCoR jurisdictions; and 118 collaborations between institutions in EPSCoR jurisdictions and in foreign countries. These collaborative efforts highlight the vast network of institutional involvement among EPSCoR jurisdictions and their partners in RII projects.

Among the 136 awards co-funded by EPSCoR in FY 2017, 66 involved collaborative research between multiple institutions. Of those 66 collaborative awards, 33 were collaborations between investigators from institutions in EPSCoR and non-EPSCoR jurisdictions.

An analysis of the gains in academic research quality and competitiveness, and in science and technology human resource development, achieved by the program over the last 5 fiscal years (Sec. 103(d)(3)).

Eligibility to participate in NSF EPSCoR programmatic activities is based upon the jurisdictions' demonstrated ability to obtain NSF research funds. Currently, a jurisdiction is eligible to participate in EPSCoR programs if its level of NSF research support is equal to or less than 0.75 percent of the total NSF research and related activities budget averaged over the most recent three-year period.

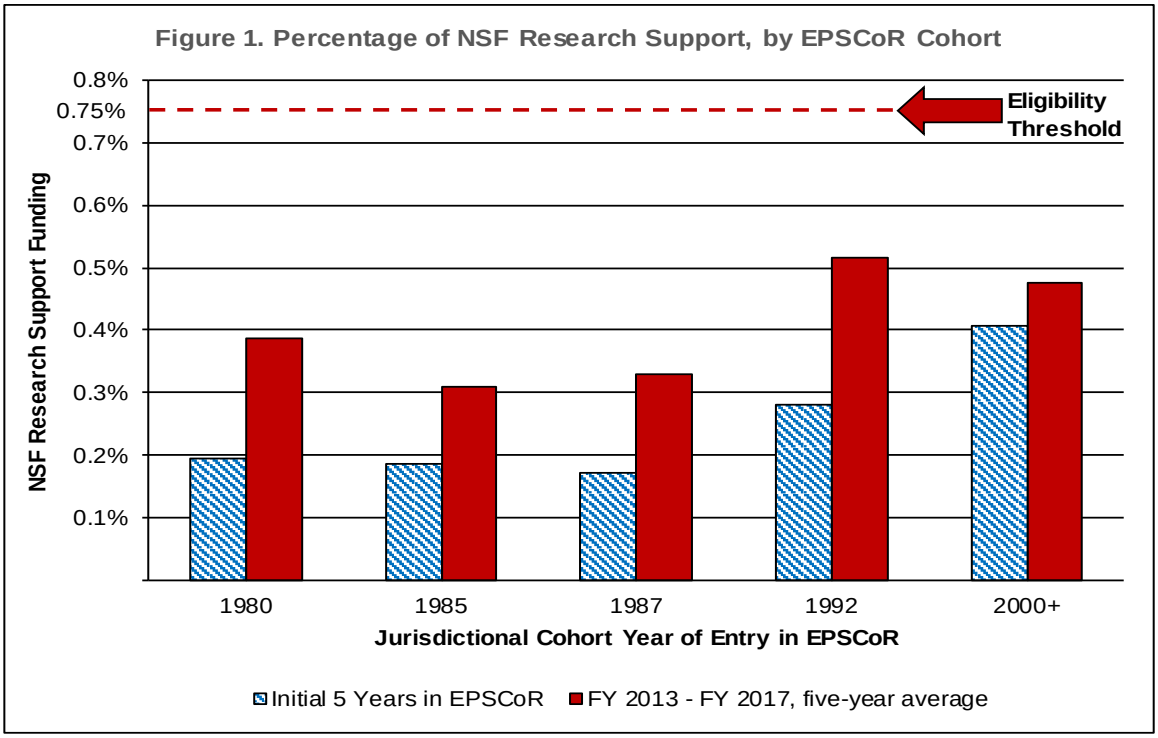
Given EPSCoR's aim to stimulate research that is fully competitive in NSF's disciplinary and multidisciplinary research programs, increases in the ability to capture NSF research funds serve as a proxy for gains in research competitiveness. As in FY 2016, Iowa, Missouri, Tennessee, and Utah exceeded the 0.75 percent threshold and these jurisdictions continued to be ineligible to compete in new RII competitions in FY 2017. Additionally, Iowa, Tennessee, and Utah exceeded the threshold for three or more consecutive years and were no longer EPSCoR-eligible for co-funding or outreach in FY 2017.

Figure 1 (below) shows the average amount of NSF research funds by cohort for the initial five years (hatched bars) and the most recent five years (solid bars) of their participation in the NSF EPSCoR Program. A cohort is defined as the group of states or jurisdictions that entered the EPSCoR program within a given fiscal year. For example, the 1980 cohort consists of the initial five states that qualified for EPSCoR: Arkansas, Maine, Montana, South Carolina, and West Virginia. For this summary, the 2000+ cohort consists of jurisdictions that entered EPSCoR in FY 2000 or later and are still EPSCoR-eligible: Alaska, Delaware, Guam, Hawaii, New Hampshire, New Mexico, Rhode Island, and the U.S. Virgin Islands. Former EPSCoR jurisdictions Iowa, Missouri, Tennessee, and Utah are excluded because they were no longer EPSCoR-eligible in FY 2017.

Each cohort shows an increase in competitiveness over the periods of participation. For example, the 1980 cohort shows a 98 percent increase in NSF research funding over the past 37 years of EPSCoR activity. The 1985 cohort (Alabama, Kentucky, Nevada, North Dakota, Oklahoma, Puerto Rico, Vermont, and Wyoming) demonstrates a 66 percent increase during its 32 years of participation in EPSCoR. The 1987 cohort (Idaho, Louisiana, Mississippi, and South Dakota) shows a 92 percent increase over the past 30 years, while the 1992 cohort (Kansas and Nebraska) has an 84 percent increase in competitiveness over its 25 years of EPSCoR involvement. Jurisdictions participating in EPSCoR since FY 2000 entered into the program at a higher level of NSF research funding than the previous cohorts. For the 2000+ cohort, there has been a small, yet demonstrable 17 percent increase in research funding. The data for each jurisdiction

is provided in the table immediately after the figure.

Figure 1. Percentage of NSF Research Support Funding by EPSCoR Cohort



Percentage of NSF Research Support Funding, by Jurisdiction and EPSCoR Cohort

	Initial 5 Years in EPSCoR	Most Recent 5 Year Period (FY 2013-2017)
1980 Cohort	0.19%	0.39%
Arkansas	0.10%	0.31%
Maine	0.27%	0.34%
Montana	0.13%	0.38%
South Carolina	0.41%	0.67%
West Virginia	0.07%	0.23%
1985 Cohort	0.19%	0.31%
Alabama	0.33%	0.48%
Kentucky	0.22%	0.41%
Nevada	0.14%	0.30%
North Dakota	0.06%	0.18%
Oklahoma	0.30%	0.53%
Puerto Rico	0.15%	0.13%
Vermont	0.10%	0.19%
Wyoming	0.20%	0.25%
1987 Cohort	0.17%	0.33%
Idaho	0.08%	0.28%
Louisiana	0.36%	0.56%
Mississippi	0.16%	0.27%
South Dakota	0.09%	0.21%
1992 Cohort	0.28%	0.52%
Kansas	0.34%	0.55%
Nebraska	0.22%	0.48%
2000+ Cohort	0.41%	0.48%
Alaska	0.55%	0.52%
Delaware	0.41%	0.55%
Guam	0.02%	0.03%
Hawaii	0.56%	0.54%
New Hampshire	0.44%	0.62%
New Mexico	0.58%	0.76%
Rhode Island	0.70%	0.73%
Virgin Islands	-	0.06%

The table below demonstrates the quantifiable outputs of NSF EPSCoR's RII Track-1 program over the last five fiscal years. This information elucidates the gains in academic research quality over time, as defined by publications, leveraged grants, and patents. For publications, primary support is defined as research that is directly funded by EPSCoR and partial support is defined as use of equipment or facilities funded by EPSCoR. The number and valuation of grants awarded encompass all federal, private industry, and private foundation awards across the U.S. in a given fiscal year for all EPSCoR jurisdictions.

Aggregate of EPSCoR Outputs (n=27*)

	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	Total
Primary Support Publications	679	591	581	409	293	2,553
Partial Support Publications	1,254	1,001	1,026	927	692	4,900
Grants Awarded	654	601	563	675	455	2,948
Value of Grants Awarded (Dollars in Millions)	$259.50	$278.80	$181.80	$379.10	$492.10	$1,591.30
Patents Awarded	12	15	13	14	17	71
Patents pending	55	38	44	34	29	200

*The maximum number of jurisdictions with active RII Track-1 awards in FY 2017. Outputs are not comparable from year-to-year due to the influx of new and expiring awards over the time period.

The table below indicates EPSCoR's ongoing support of human resource development over the last five fiscal years in the RII Track-1 program. The number of faculty and students involved in RII Track-1 projects have remained fairly constant over time, signifying a strong commitment by NSF and the jurisdictions in strengthening jurisdictional human capital in science and engineering research and education.

EPSCoR Human Resource Development

	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	Total
Faculty Supported	1,535	1,581	1,602	1,552	1,183	**N/A***
Post-Docs Supported	211	215	231	200	156	**N/A***
Graduate Students Supported	1,383	1,346	1,361	1,332	1,056	**N/A***
Undergraduates Supported	1,955	1,867	1,965	1,861	1,220	**N/A***
New Faculty Hired	60	73	89	84	54	**360**
Graduate Degrees Conferred	305	326	245	258	254	**1,388**
Undergraduate Degrees Conferred	376	380	408	404	634	**2,202**

* The number of faculty and students supported are not summed because many of them remain tied to their respective projects for the duration of the award and would, therefore, be double-counted over time.

Additionally, NSF EPSCoR is working with NSF's Office of Integrative Activities, Evaluation and Assessment Capability section to develop a cohesive evaluation framework for the program. This evaluation will address the legislative objective of increasing the research competitiveness of jurisdictions receiving EPSCoR funding. The evaluation is informed by the findings and recommendations from the EPSCoR retrospective evaluation completed by the Science and Technology Policy Institute (STPI) in 2012. Part of this effort involves an evaluation contract that will (1) develop a flexible framework to explore, define, and measure research competitiveness in relation to the unique jurisdictional contexts and (2) use evidence of jurisdictional progress toward research competitiveness over time for strategic program improvement.

RESEARCH AND RELATED ACTIVITIES (R&RA) **$6,150,680,000**
+$144,170,000 / 2.4%

The FY 2019 Budget Request for the Research and Related Activities (R&RA) account is $6,150.68 million. Funding within the R&RA Appropriation invests in early-stage research as well as development of a future-focused science and engineering workforce that can support the private sector and accelerate progress in basic science and engineering research.

NSF is the only federal agency dedicated to funding basic research across all areas of science and engineering. In FY 2019, NSF will continue its longstanding commitment to investing in learning and discovery that will promote the innovations that will be the foundation for the Nation's future prosperity.

R&RA Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 Annualized CR	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Biological Sciences	$742.22	-	$738.16	-$4.06	-0.5%
Computer & Information Science and Engineering	935.93	-	925.42	-10.51	-1.1%
Engineering	930.92	-	921.43	-9.49	-1.0%
Geosciences	825.62	-	852.98	27.36	3.3%
Mathematical & Physical Sciences	1,362.43	-	1,345.32	-17.11	-1.3%
Social, Behavioral & Economic Sciences	270.89	-	246.19	-24.70	-9.1%
Office of International Science and Engineering	48.96	-	48.50	-0.46	-0.9%
Office of Polar Programs	467.85	-	534.54	66.69	14.3%
Integrative Activities	420.27	-	536.72	116.45	27.7%
U.S. Arctic Research Commission	1.43	-	1.42	-0.01	-0.7%
Total, R&RA	**$6,006.51**	**$5,992.67**	**$6,150.68**	**$144.17**	**2.4%**

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; ~~$5,361,650,000,~~*$6,150,680,000,* to remain available until September 30, ~~2019,~~*2020,* of which not to exceed ~~$500,000,000~~*$500,000,000* 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.

Note.—A full-year 2018 appropriation for this account was not enacted at the time the budget was prepared; therefore, the budget assumes this account is operating under the Continuing Appropriations Act, 2018 (Division D of P.L. 115–56, as amended). The amounts included for 2018 reflect the annualized level provided by the continuing resolution.

Research and Related Activities
FY 2019 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 2017 Appropriation	$6,033.65	$11.93	-$33.33	$22.26	-$28.00	$6,006.51
FY 2018 Annualized CR	5,992.67	33.33				6,026.00
FY 2019 Request	6,150.68					6,150.68
$ Change from FY 2018 Annualized CR						$124.68
% Change from FY 2018 Annualized CR						2.1%

Explanation of Carryover

Within the Research and Related Activities (R&RA) account, $33.88 million (including $554,458 in reimbursable funds) was carried over into FY 2018.

Directorate for Geosciences Polar Programs (no-year funding)
- Amount: $4.10 million
- Reason: Recoveries from prior year obligations that were received too late in the fiscal year to obligate.
- Obligation: Anticipated FY 2018 Quarter 4

Integrative Activities (IA)
- Amount: $770,880
- Reason: Funds to support Proposal Management Efficiencies contracts that were not ready for obligation in FY 2017.
- Obligation: Anticipated FY 2018 Quarter 2

IA for HBCU Excellence in Research Program
- Amount: $10.0 million
- Reason: These carryover funds will be used for awards that were not ready for obligation in FY 2017.
- Obligation: Anticipated FY 2018 Quarter 2

IA for Hispanic Serving Institution Program
- Amount: $15.0 million
- Reason: These carryover funds will be used for awards that were not ready for obligation in FY 2017.
- Obligation: Anticipated FY 2018 Quarter 2

National Coordination Office for Networking and Information Technology Research and Development
- Amount: $749,261
- Reason: Operational funds are needed to continue government procurements and operations.
- Obligation: Anticipated FY 2018 Quarter 2

National Nanotechnology Coordination Office (NNCO)

- Amount: $349,974
- Reason: NNCO's carryover will be used to fund the required Quadrennial Review of the National Nanotechnology Initiative. In addition, funds carried over will be used to cover rent in NNCO's new location.
- Obligation: Anticipated FY 2018 Quarter 2

The remaining R&RA carryover of $2.36 million consists of funds from throughout the Foundation for selected projects that were not ready for obligation in FY 2017.

BIOLOGICAL SCIENCES (BIO) **$738,160,000**
-$4,060,000 / -0.5%

BIO Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Percent
Molecular and Cellular Biosciences (MCB)	$137.02	-	$137.69	$0.67	0.5%
Integrative Organismal Systems (IOS)	215.63	-	184.97	-30.66	-14.2%
Environmental Biology (DEB)	145.42	-	146.16	0.74	0.5%
Biological Infrastructure (DBI)	130.35	-	175.14	44.79	34.4%
Emerging Frontiers (EF)	113.80	-	94.20	-19.60	-17.2%
Total	**$742.22**	**-**	**$738.16**	**-$4.06**	**-0.5%**

About BIO

The Directorate for Biological Sciences (BIO) supports research that sheds light on the principles and mechanisms governing life across all scales and complexities, from individual biological molecules to ecosystems. This basic research enables discoveries that ultimately achieve significant downstream impact through collaboration with other scientific disciplines and application of science to improve quality of life. The span of investigation is reflected in a variety of specific interests, including Understanding the Rules of Life (URoL), the National Ecological Observation Network (NEON), and Understanding the Brain (UtB). A commitment to integrate research and education, broaden participation, and promote international partnerships is integral to all activities across the directorate.

In FY 2019, research that aligns with the comprehensive BIO framework, URoL, will continue. Gaining an understanding of the complex relationships between genotype and phenotype in plants, animals, and microbes across scales of size, time, and place is a grand challenge not easily achieved. Support for early investigators to ensure adequate numbers of researchers prepared to tackle these difficult and complex questions is critical to success and requires a long-term investment.

U.S. academic research in the biological sciences depends on NSF funding; BIO considers this role essential to the promotion of vibrant and innovative fundamental biological research at U.S. universities and colleges. Broad support for biology is necessary to produce knowledge relevant to national needs in food, health, energy, and environment. Additionally, support for biological research will continue a stream of economic innovations that contribute to American livelihoods, as demonstrated by progress in areas such as biofuels, biorenewable chemicals, and nanotechnology.

BIO increasingly supports projects that address comprehensive questions involving multiple types of data acquisition and levels of analysis. These projects are becoming larger and more collaborative both within the biological sciences and with other fundamental disciplines. Because of its broad mission, NSF is one of the few agencies where support for such integration across disciplines is possible.

FY 2019 priorities for BIO include:

- URoL: First introduced in FY 2017, support for URoL will continue in FY 2019, emphasizing research areas such as the genotype to phenotype challenge, plant- and animal-organismal interactions, and developing biological theory as a framework for the rules of life. Quantitative approaches that integrate the mathematical and physical sciences, computer science, and engineering to advance basic biological understanding will continue to be encouraged.

- NEON: With the construction of NEON scheduled to complete in fall 2018, BIO will assume responsibility for full operations and maintenance (O&M) and oversight funding, in FY 2019. NEON O&M funding is included in the budget for the Division of Biological Infrastructure (DBI). Support for NEON-science is a priority investment across BIO and designed to achieve the promise of this major new facility and its exciting capabilities. For more information on NEON, see the MREFC chapter.

- UtB, including the BRAIN Initiative: This cross-agency priority will continue in FY 2019. BIO funding for UtB, including the BRAIN Initiative, will support investments designed to enable the transformational research, engineering, infrastructure development, and training required to accomplish the overall multi-year goal and includes support for the Next Generation Networks for Neuroscience (NeuroNex) program. Additional information for UtB is available in the NSF-Wide Investments chapter.

BIO provides 69 percent of the federal funding for basic research at academic institutions in non-medical biology.

Major Investments

BIO Major Investments
(Dollars in Millions)

Area of Investment	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
CAREER	$36.71	-	$36.01	-$0.70	-1.9%
IUSE	1.82	-	2.00	0.18	9.8%
NSF I-Corps™	1.00	-	1.00	0.00	0.1%
NSF Research Traineeship[1]	2.82	-	-	-2.82	-100.0%
Understanding the Brain	46.39	-	46.00	-0.39	-0.8%
BRAIN Initiative	*20.77*	*-*	*19.54*	*-1.23*	*-5.9%*
NSF's Big Ideas					
NSF INCLUDES[2]	*1.20*	*-*	*-*	*-1.20*	*-100.0%*
Understanding the Rules of Life	*-*	*-*	*30.00*	*30.00*	*N/A*

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

[1]In FY 2019, NRT funding is provided through CISE and EHR.

[2]In FY 2019, NSF INCLUDES funding is provided through the EHR account.

BIO Funding for Centers Programs and Facilities

BIO Funding for Centers Programs
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Total	**$36.13**	**-**	**$18.10**	**-$18.03**	**-49.9%**
Centers for Analysis & Synthesis (DBI)	15.80	-	4.40	-11.40	-72.2%
Nanoscale Science & Engineering Centers (DBI)	5.33	-	-	-5.33	-100.0%
STC: Bio/computational Evolution in Action CONsortium (BEACON) (DBI)	5.00	-	3.70	-1.30	-26.0%
STC: Biology with X-ray Lasers (BioXFEL) (DBI)	5.00	-	5.00	-	-
STC: Center for Cellular Construction (CCC) (DBI)	5.00	-	5.00	-	-

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

BIO Funding for Facilities
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Total	**$55.61**	**-**	**$65.35**	**$9.74**	**17.5%**
National Ecological Observatory Network (NEON)	50.26	-	65.00	14.74	29.3%
Cornell High Energy Synchrotron Source (CHESS)	5.00	-	-	-5.00	-100.0%
National Nanotechnology Coordinated Infrastructure (NNCI)	0.35	-	0.35	-	-

For detailed information on individual facilities, please see the Facilities and the Major Research Equipment and Facilities Construction chapters.

Funding Profile

BIO Funding Profile

	FY 2017 Actual Estimate	FY 2018 (TBD)	FY 2019 Estimate
Statistics for Competitive Awards:			
Number of Proposals	5,010	-	5,200
Number of New Awards	1,147	-	1,100
Funding Rate	23%	-	21%
Statistics for Research Grants:		-	
Number of Research Grant Proposals	4,002	-	4,400
Number of Research Grants	829	-	800
Funding Rate	21%	-	18%
Median Annualized Award Size	$196,229	-	$196,200
Average Annualized Award Size	$221,619	-	$221,600
Average Award Duration, in years	3.2	-	3.2

People Involved in BIO Activities

Number of People Involved in BIO Activities

	FY 2017 Actual Estimate	FY 2018 (TBD)	FY 2019 Estimate
Senior Researchers	3,564	-	3,500
Other Professionals	1,399	-	1,300
Postdoctoral Associates	1,346	-	1,300
Graduate Students	2,662	-	2,500
Undergraduate Students	4,898	-	4,800
K-12 Teachers	-	-	-
K-12 Students	-	-	-
Total Number of People	**13,869**	**-**	**13,400**

Program Monitoring and Evaluations

Program Evaluations and Studies:

- In FY 2016, the Division of Environmental Biology (DEB) and the Division of Integrative Organismal Systems (IOS) contracted Abt Associates to conduct an external evaluation of the preliminary proposal review process. A report from Abt Associates was submitted in CY 2017 and made available on the NSF website[1]. The report was instrumental in the decision to end the preliminary proposal review process and switch to a no-deadline, full proposal review system. In FY 2018, BIO issued a Dear Colleague Letter[2] to inform the community of this switch and it is being implemented in all BIO divisions beginning in CY 2018.
- In FY 2018, BIO will initiate an evaluation of the Macrosystems Biology and Early NEON Science program within the Division of Emerging Frontiers (EF). The evaluation will consider the program's portfolio of awards, the research community stakeholder input, as well as input from other NSF directorates. The results of this evaluation will inform solicitations to enhance the use of NEON data and infrastructure.
- In FY 2018, BIO will solicit external expert advice to inform the Rules of Life framework and, in part, the future of functional genomics in plants and animals.
- In early FY 2019, BIO is planning to implement an assessment of the NeuroNex program within EF. The results of this assessment will determine future program investments.
- In FY 2019, BIO will solicit advice on emerging areas of research using biological research collections, either vouchered biodiversity specimens or living stocks, and the collections' associated digitized data and metadata. The results of this assessment will determine future directorate investments.

Workshops and Reports:

- IOS research investments in FY 2019 will be informed, in part, by the 2015 NSF-sponsored workshop report "Unpacking the Phenotype (UP) Deciphering Genome to Phenome Relationships: Interdisciplinary Research at the Interface of the Biological and Mathematical Sciences"[3]. The report informs IOS's research interests related to the Rules of Life priority.
- The Division of Molecular and Cellular Biology (MCB) supported multiple workshops that have and continue to inform the planning of the division's research programs.
    - Workshops entitled "Finding your inner modeler: how computational biology can advance your research and how to get started" were initiated in FY 2017. The series of workshops were developed to promote the use of computational modeling by cell biologists. Over the next three years, MCB will track the impact of the workshops on the quality and number of modeling proposals submitted and funded by the division.
    - A workshop entitled "The Role of Crowdfunding in the STEM Ecosystem" was held in early FY 2018. The workshop was convened to examine the practice, benefits, challenges, and limitations of using crowdfunding to finance basic research in the fields of science, technology, engineering, and mathematics.

Committee of Visitors (COV):

- In 2018, COVs will review programs in IOS and MCB.
- In 2019, COVs will review programs in DEB.

[1]www.nsf.gov/bio/pubs/reports/DEB_IOS_Review_Abt%20Final%20_report_Mar17.pdf
[2]www.nsf.gov/pubs/2018/nsf18011/nsf18011.jsp
[3]www.nsf.gov/mps/dms/documents/Deciphering_Genome-to-Phenome_Relationships.pdf

DIVISION OF MOLECULAR AND CELLULAR BIOSCIENCES (MCB) **$137,690,000**
+$670,000 / 0.5%

MCB Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Total	**$137.02**	**-**	**$137.69**	**$0.67**	**0.5%**
Research	**133.64**	**-**	**135.85**	**2.21**	**1.7%**
CAREER	14.82	-	14.39	-0.43	-2.9%
Education	**3.38**	**-**	**1.84**	**-1.54**	**-45.6%**

MCB Summary

MCB supports fundamental interdisciplinary research to uncover the basic principles that describe how information content in cells guides expression of cellular characteristics and is maintained and transmitted to the next generation; how material and energy are taken up, transformed, and flow through biological systems; and how biological molecules, which assemble into complex structures and compartments with varied functions, contribute to the processes required for life. Research at the molecular and cellular scales provides the basis for understanding normal cell processes and healthy cell function. This understanding enables the development of design rules for engineering molecules and cells that contribute both to basic research and to applications in biomanufacturing, food security, environment, and healthcare.

In general, 67 percent of the MCB portfolio is available for new research grants and 33 percent is available for continuing grants.

DIVISION OF INTEGRATIVE ORGANISMAL SYSTEMS (IOS) **$184,970,000**
-$30,660,000 / -14.2%

IOS Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Total	**$215.63**	**-**	**$184.97**	**-$30.66**	**-14.2%**
Research	**201.30**	**-**	**175.02**	**-26.28**	**-13.1%**
CAREER	13.07	-	11.00	-2.07	-15.9%
Education	**4.58**	**-**	**3.13**	**-1.45**	**-31.7%**
Infrastructure	**9.74**	**-**	**6.82**	**-2.92**	**-30.0%**
Research Resources	9.74	-	6.82	-2.92	-30.0%

IOS Summary

IOS supports research at the level of organisms, the mid-scale of biological organization between molecular/cellular and populations/ecosystems. Research and education support is 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 these processes are integrated to result in the dynamic stability of whole organisms. Achieving such a systems-level understanding of organisms is fundamental to the overall understanding of the organizing principles and mechanisms behind the vast diversity of life on earth.

IOS encourages synthetic and interdisciplinary approaches and development of new tools through the Enabling Discovery through Genomic Tools (EDGE) program. These approaches span computational, mathematical, and organismal levels of inquiry and analysis. IOS-supported research affords new understanding of how a wide variety of plants, animals, microbes, and fungi respond and adapt to change to improve our understanding of the reciprocal interactions between the biological and physical worlds. Supported research includes comparative and evolutionary approaches to expose common patterns of developmental, neural, and physiological mechanisms underlying how organisms perceive and respond to their physical and social environment. Results of IOS-supported research will provide the information needed to enable multi-scale integration of these dynamic activities to reveal emergent properties at other biological, spatial and temporal scales. IOS-supported research is relevant to societal goals for food security, sustainability, understanding organismal responses to environmental and social stressors, and understanding the healthy brain.

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

DIVISION OF ENVIRONMENTAL BIOLOGY (DEB) **$146,160,000**
+$740,000 / 0.5%

DEB Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Total	**$145.42**	**-**	**$146.16**	**$0.74**	**0.5%**
Research	**142.67**	**-**	**144.14**	**1.47**	**1.0%**
CAREER	4.92	-	3.86	-1.06	-21.6%
Education	**2.59**	**-**	**2.02**	**-0.57**	**-21.9%**
Infrastructure	**0.17**	**-**	**-**	**-0.17**	**-100.0%**

DEB Summary

DEB supports fundamental research on Earth's biodiversity and the ecological and evolutionary processes that explain the origin and maintenance of genetic variation in nature, including its history and patterns of speciation and extinction. DEB supported research also advances understanding of the functional importance of our natural biodiversity heritage to ecological and ecosystem processes occurring over short and long temporal and spatial scales. The discoveries from this research help the nation to wisely develop, use, and sustain its biological resources, including natural, agricultural, and other managed ecosystems, and to forecast changes in species populations and ecosystems over time.

DEB funded research provides the data, knowledge, and capability to predict the spread of infectious diseases and of invasive species, and their impacts on wild, managed, and agricultural systems. Models developed from biodiversity and ecological research are used to predict environmental drivers of conflict, enhance the nation's ability to strategically prepare for environmental threats, and to field defense and mitigation capabilities that are resilient and adaptive.

In general, 67 percent of the DEB portfolio is available for new research grants. The remaining 33 percent supports continuing grants made in prior years.

DIVISION OF BIOLOGICAL INFRASTRUCTURE (DBI) **$175,140,000**
+$44,790,000 / 34.4%

DBI Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Total	**$130.35**	**-**	**$175.14**	**$44.79**	**34.4%**
Research	**43.39**	**-**	**43.08**	**-0.31**	**-0.7%**
CAREER	3.90	-	5.00	1.10	28.3%
Centers Funding (total)	36.13	-	18.10	-18.03	-49.9%
Centers for Analysis & Synthesis	15.80	-	4.40	-11.40	-72.2%
Nanoscale Science & Engineering Centers	5.33	-	-	-5.33	-100.0%
STC: Bio/computational Evolution in Action CONsortium (BEACON) (DBI)	5.00	-	3.70	-1.30	-26.0%
STC: Biology with X-ray Lasers (BioXFEL)	5.00	-	5.00	-	-
STC: Center for Cellular Construction (CCC)	5.00	-	5.00	-	-
Education	**24.14**	**-**	**19.52**	**-4.62**	**-19.1%**
Infrastructure	**62.83**	**-**	**112.54**	**49.71**	**79.1%**
NEON	-	-	65.00	65.00	N/A
CHESS	5.00	-	-	-5.00	-100.0%
NNCI	0.35	-	0.35	-	-
Research Resources	57.48	-	47.19	-10.29	-17.9%

DBI Summary

DBI empowers biological discovery by supporting the development and enhancement of biological research resources, human capital, and facilities. In particular, DBI supports the development of, or improvements to research infrastructure, including cyberinfrastructure; instrumentation; and improvements to biological research collections, living stock collections, and field stations and marine labs. In addition, DBI supports the development of human capital through undergraduate, and postdoctoral research experiences. Support for facilities like NEON create opportunities to address targeted, but deep biological questions that have major societal impact particularly with respect to ecological forecasting.

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

DIVISION OF EMERGING FRONTIERS (EF) **$94,200,000**
-$19,600,000 / -17.2%

EF Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Total	**$113.80**	**-**	**$94.20**	**-$19.60**	**-17.2%**
Research	**61.42**	**-**	**93.95**	**32.53**	**53.0%**
CAREER	-	-	1.76	1.76	N/A
Big Idea: Understanding the Rules of Life	-	-	30.00	1.76	N/A
Education	**2.12**	**-**	**0.25**	**-1.87**	**-88.2%**
Infrastructure	**50.26**	**-**	**-**	**-50.26**	**-100.0%**
NEON	50.26	-	-	-50.26	-100.0%

EF Summary

EF identifies, incubates, and supports research areas and infrastructure that transcend scientific disciplines and/or advance conceptual foundations across all of biology. EF also facilitates the development and implementation of new forms of merit review and mechanisms to support transformative research and stimulate creativity (such as Ideas Labs). New programs and priority areas, especially those that are cross-cutting, typically begin development in EF and then move to other BIO divisions to become part of the disciplinary knowledge base. An example is NEON which transitioned from EF to DBI across FY 2017 and FY 2018. In FY 2019, EF is responsible for the financial stewardship of new investments in NSF's Big Idea, Understanding the Rules of Life. It will also provide support for cross-cutting activities that contribute to research that crosses spatial and temporal scales, as well as levels of biological organization.

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

DIRECTORATE FOR COMPUTER AND INFORMATION SCIENCE AND ENGINEERING (CISE) **$925,420,000 -$10,510,000/ -1.1%**

CISE Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Percent
Office of Advanced Cyberinfrastructure (OAC)	$223.36	-	$210.09	-$13.27	-5.9%
Computing and Communication Foundations (CCF)	193.57	-	183.03	-10.54	-5.4%
Computer and Network Systems (CNS)	231.36	-	217.09	-14.27	-6.2%
Information and Intelligent Systems (IIS)	194.58	-	192.07	-2.51	-1.3%
Information Technology Research (ITR)	93.06	-	123.14	30.08	32.3%
Total	**$935.93**	**-**	**$925.42**	**-$10.51**	**-1.1%**

About CISE

Advances in information technology (IT) over the past two decades have proven to be key drivers of the American economy. Essentially all practical applications of today's IT are based on ideas and concepts that emerged from investments in fundamental computing research, many of them funded by CISE.[1] Fundamental ideas and concepts advanced through computing research have enabled innovative products and applications that now permeate many aspects of daily life, including personal communications, energy, transportation, health care, advanced manufacturing, national and homeland security, disaster preparedness and response, education and workforce development, public and private organizational effectiveness and efficiency, and discovery and innovation at the frontiers of all areas of scientific and engineering research. Maintaining American leadership in IT and its applications, including in artificial intelligence and machine learning, augmented and virtual reality, data science, intelligent civil infrastructure, quantum computing and communication, and research cyberinfrastructure for all domains, will require sustained investment. Indeed, CISE must continue to play a central and leadership role in improving America's economic outlook and advancing a highly-trained, technologically astute, and diverse American workforce.

Specifically, 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 across the science and engineering research enterprise; to promote understanding of the principles and uses of advanced computer, communication, and information systems in advancing science and engineering and 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 subfields 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 an American workforce with computing and computational competencies essential to success in an increasingly competitive global market. CISE executes its mission through its Divisions of Computing and Communication Foundations (CCF), Computer and Network Systems (CNS), Information and Intelligent Systems (IIS), and Information and Technology Research (ITR), and the Office of Advanced Cyberinfrastructure (OAC)—and in close partnership with other NSF units, federal agencies, international funders, and the private sector, including foundations, private companies, and nonprofits.

CISE's FY 2019 Budget Request is shaped by support for several of NSF's 10 Big Ideas for Future NSF Investments, including co-leadership of Harnessing the Data Revolution for 21st-Century Science and

[1] www.nap.edu/catalog.php?record_id=13427

Engineering (HDR), Future of Work at the Human-Technology Frontier (FW-HTF), and The Quantum Leap (QL): Leading the Next Quantum Revolution; support for several ongoing NSF-wide priority areas, including Improving Undergraduate STEM Education; NSF Innovation Corps™ (NSF I-Corps™); NSF Research Traineeship (NRT); Secure and Trustworthy Cyberspace (SaTC); and Understanding the Brain (UtB); and support for the all-of-government National Strategic Computing Initiative (NSCI).

As part of HDR, and in partnership with the other research directorates and offices, CISE will invest funds in its ITR division to support convergent activities that transcend the traditional disciplinary boundaries of individual NSF directorates and offices. These activities will enable pursuit of fundamental research in data science and engineering; the development of a cohesive, federated, national-scale approach to research data infrastructure; and the development of a 21st-century data-capable workforce. While budget management and reporting for this ITR investment will be the responsibility of CISE, the convergent activities will be overseen and managed collaboratively by the multi-directorate/office HDR leadership team. Also through HDR, and with funds from all of its divisions and office, CISE will continue to support key foundational programs, including Critical Techniques, Technologies and Methodologies for Advancing Foundations and Applications of Big Data Science; Cyberinfrastructure for Sustained Scientific Innovation (CSSI): Data Elements, Frameworks, and Community Cyberinfrastructure; EarthCube; and Transdisciplinary Research in Principles of Data Science. Collectively, these investments will complement the HDR Convergence Accelerator based in the NSF Office of Integrative Activities (OIA), which will support translational activities in partnership with other federal agencies, the private sector, and international funders.

CISE will also actively participate in FW-HTF, building on a long history of foundational investment in this area to advance understanding of how constantly-evolving technologies are changing the world of work and the lives of American workers, and how Americans can in turn shape these technologies. As part of FW-HTF, CISE will continue to support Cyber-Physical Systems, Cyberlearning for Work at the Human-Technology Frontier, National Robotics Initiative 2.0: Ubiquitous Collaborative Robots, Smart & Connected Communities, and Smart and Connected Health.

CISE investments in QL will focus on experimental platforms enabling exploration of novel quantum computing approaches, support for faculty and students to enhance capacity within the CISE research community, and the development of new instructional materials and pedagogical approaches for quantum computing education.

In partnership with other NSF directorates and offices, CISE will also participate in the Navigating the New Arctic and Understanding the Rules of Life Big Ideas.

CISE, through OAC, will co-lead NSCI with the Directorate for Mathematical and Physical Sciences (MPS) and, in partnership with other NSF directorates and offices, will represent NSF in its leadership role for NSCI across the federal government. CISE will support research advances in new computing technologies, architectures, and platforms for the future, as well as the development and deployment of advanced high-performance computing (HPC) systems, including maximizing the benefits of these systems through the deep integration of cyberinfrastructure with science and engineering research. As part of NSCI, CISE will support Computational and Data-Enabled Science and Engineering, CSSI: Software Elements, Frameworks, and Community Cyberinfrastructure, and Scalable Parallelism in the Extreme.

In addition, CISE continues to provide leadership for the federal Networking and Information Technology Research and Development (NITRD) program. The NITRD Subcommittee of the National Science and Technology Council, which coordinates investments in networking and information technology research and development across more than 20 federal departments, agencies, and offices, is co-chaired by the NSF assistant director for CISE. All research, education, and research infrastructure projects supported by CISE contribute to NSF's NITRD portfolio.

CISE will also continue to place a priority on developing partnerships with other NSF units, federal agencies, and international funders, and especially with the private sector, including private industry, foundations, and nonprofits, as an increasingly important means to maximize the scientific, economic, and societal impacts of its investments. These external partnerships leverage resources, inform use-inspired research, accelerate the transition of research innovations to practice, and enhance workforce development.

CISE provides about 83 percent of the federal funding for fundamental computer science research at U.S. academic institutions.

Major Investments

CISE Major Investments
(Dollars in Millions)

Area of Investment	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
ADVANCE	$3.58	-	-	-$3.58	-100.0%
CAREER	49.69	-	46.85	-$2.84	-5.7%
IUSE	1.99	-	2.00	0.01	0.5%
NSF I-Corps™	11.65	-	11.65	-	-
NSF Research Traineeship	7.10	-	10.95	3.85	54.2%
SaTC	73.00	-	65.75	-7.25	-9.9%
Understanding the Brain	25.84	-	22.15	-3.69	-14.3%
BRAIN Initiative	*10.67*	*-*	*9.50*	*-1.17*	*-11.0%*
NSF's Big Ideas		-			
Harnessing the Data Revolution	*-*	*-*	*30.00*	*30.00*	*N/A*
NSF INCLUDES	*1.52*	*-*	*-*	*-1.52*	*-100.0%*

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

While CISE will continue to participate in ADVANCE: Increasing the Participation and Advancement of Women in Academic Science and Engineering Careers (ADVANCE) and Inclusion across the Nation of Learners of Underrepresented Discoverers in Engineering and Science (NSF INCLUDES) in FY 2019, the funds for these NSF-wide education-related programs will be centrally located in EHR.

CISE Funding for Centers Programs and Facilities

CISE Funding for Centers Programs
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Total	**$10.00**	**-**	**$8.70**	**-$1.30**	**-13.0%**
STC: Center for the Science of Information (CCF)	5.00	-	3.70	-1.30	-26.0%
STC: Center for Brains, Minds and Machines: The Science and the Technology of Intelligence (CCF, IIS, ITR)	5.00	-	5.00	-	-

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

CISE Funding for Facilities
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change Over FY 2017 Actual Amount	Change Over FY 2017 Actual Percent
Total, Facilities	**$0.60**	**-**	**$0.60**	**-**	**-**
National Nanotechnology Coordinated Infrastructure (NNCI) Program (CCF)	0.60	-	0.60	-	-

For detailed information on individual facilities, see the Facilities and the Major Research Equipment and Facilities Construction chapters.

Funding Profile

CISE Funding Profile

	FY 2017 Actual Estimate	FY 2018 (TBD)	FY 2019 Estimate
Statistics for Competitive Awards:			
Number of Proposals	8,723	-	9,500
Number of New Awards	1,819	-	1,800
Funding Rate	21%	-	19%
Statistics for Research Grants:			
Number of Research Grant Proposals	8,390	-	9,100
Number of Research Grants	1,547	-	1,530
Funding Rate	18%	-	17%
Median Annualized Award Size	$156,667	-	$150,000
Average Annualized Award Size	$188,410	-	$180,000
Average Award Duration, in years	2.9	-	3.0

Number of People Involved in CISE Activities

Number of People Involved in CISE Activities			
	FY 2017 Actual Estimate	FY 2018 (TBD)	FY 2019 Estimate
Senior Researchers	7,230	-	7,200
Other Professionals	1,086	-	1,050
Postdoctoral Associates	489	-	450
Graduate Students	6,359	-	6,300
Undergraduate Students	2,624	-	2,600
K-12 Teachers	-	-	-
K-12 Students	-	-	-
Total Number of People	**17,788**	**-**	**17,600**

Program Monitoring and Evaluation

Committees of Visitors (COV)

- In early FY 2018, OAC convened a Committee of Visitors (COV) to examine and assess the quality of the merit review process across the Office. The report from the COV will be presented to the Advisory Committee for Cyberinfrastructure (ACCI) at its Spring 2018 meeting.

Program Evaluations

- In FY 2012, the Science and Technology Policy Institute (STPI) conducted a program evaluation feasibility study for SaTC. This feasibility study provided methods for examining baseline portfolio investments and identifying metrics to measure progress toward program goals. It was part of a broader effort to develop a plan for a future impact assessment. STPI identified baseline evaluation metrics in FY 2013 - FY 2015, and completed the evaluation feasibility study in FY 2016. CISE, together with the NSF Evaluation and Assessment Capability (EAC), funded a program evaluation of SaTC in FY 2016; that program evaluation is currently underway.
- Evaluation is a key part of CISE's education programs. All K-12 computer science education projects managed by CISE include rigorous research and evaluation plans designed to guide project progress and measure project impacts. CISE also tasked STPI to conduct an evaluation feasibility study for STEM+C Partnerships, and the Education Development Center, Inc. (EDC) to develop a program evaluation instrument for legacy K-12 computer science education projects. The first program evaluation of these projects is currently underway.

Reports

- In 2008, CISE funded the Computer Science and Telecommunications Board (CSTB) within the National Academy of Sciences, Engineering, and Medicine to study the IT innovation ecosystem and to assess the long-term economic impacts of CISE investments. The resulting report, *Assessing the Impacts of Changes in the Information Technology R&D* Ecosystem,[2] 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

[2]www.nap.edu/catalog.php?record_id=12174

investments. The National Academies published the resulting report, *Continuing Innovation in Information Technology*, in 2012.[3] A more recent CSTB study, *Continuing Innovation in Information Technology: A Workshop* (described below), employed this report's framework.

- In FY 2012, a CSTB study, *The Future of Computing Performance: Game Over or Next Level?*,[4] together with a white paper from the CISE-funded Computing Community Consortium (CCC), *21st Century Computer Architecture*,[5] outlined the need for advances in computer architecture research, leading to the development of the Exploiting Parallelism and Scalability (XPS) program in FY 2013. In FY 2019, CISE will continue to invest in advanced computer architecture research through the Scalable Parallelism in the Extreme (SPX) program, leveraging past investments in XPS, as part of NSCI.
- 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;[6] this led to the development of the NSFFutureCloud program, which began in FY 2014 and entered a second phase in FY 2017. In FY 2019, CISE will continue to invest in NSFFutureCloud.
- Since FY 2014, the CCC has led several additional community visioning efforts that have the potential to influence CISE programs in FY 2019:
  - *Computing Visions 2025:*[7] inspired 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.*
  - *Toward a Science of Autonomy for Physical Systems:*[8] offered a series of white papers framing the challenges and opportunities associated with a future of autonomous physical systems across a range of domains including health care, transportation, and disaster response. These white papers have the potential to influence CISE investments in CPS and NRI-2.0.
  - *A New Age of Computing and the Brain:* brought together computer and information scientists and engineers and brain scientists to explore opportunities and connections at the intersection of computer and information science and brain science. The resultant workshop report summarizing the key findings has the potential to influence CISE and NSF investments in UtB.[9]
  - *Intelligent Infrastructure:*[10] presented a national research agenda for intelligent infrastructure, or the deep embedding of sensing, computation, and communication capabilities into traditional physical infrastructure such as roads, bridges, railways, and buildings, for enhancing efficiency, resiliency, and safety. These white papers, which the CCC produced jointly with the Electrical and Computer Engineering Department Heads Association (ECEDHA), have the potential to influence CISE investments in S&CC.
- Similarly, since FY 2014, CISE has funded several CSTB studies that have the potential to influence CISE programs in FY 2019:
  - *Continuing Innovation in Information Technology: A Workshop:* conducted a public workshop to highlight additional examples of the impacts of computing research using the framework established in the "tire tracks" figure published in CSTB's 2012 report *Continuing Innovation in Information Technology*. The resultant workshop report was published in 2016.[11]
  - *Toward 21st-Century Cyber-Physical Systems Education:* published a report in 2016 on the current

[3] www.nap.edu/catalog.php?record_id=13427
[4] www.nap.edu/openbook.php?record_id=12980
[5] http://cra.org/ccc/docs/init/21stcenturyarchitecturewhitepaper.pdf
[6] http://cra.org/ccc/visioning/visioning-activities/mid-scale-infrastructure-investments-for-computing-research
[7] http://cra.org/ccc/visioning/computing-visions-2025/
[8] http://cra.org/ccc/resources/ccc-led-whitepapers/#toward-a-science-of-autonomy-for-physical-systems
[9] http://cra.org/ccc/wp-content/uploads/sites/2/2014/12/BRAIN-Report.pdf
[10] http://cra.org/ccc/resources/ccc-led-whitepapers/#infrastructure
[11] https://www.nap.edu/catalog/23393/continuing-innovation-in-information-technology-workshop-report

and future needs in education for cyber-physical systems (CPS), articulating a vision for a 2l[st]-century CPS-capable U.S. workforce.[12]

- *Future Directions for NSF Advanced Computing Infrastructure to Support U.S. Science in 2017-2020:* published a report in 2016 on anticipated priorities and associated tradeoffs for advanced computing in support of NSF-sponsored science and engineering research, yielding recommendations in support of four broad goals: (1) position the United States for continued leadership in science and engineering, (2) ensure that resources meet community needs, (3) aid the scientific community in keeping up with the revolution in computing, and (4) sustain the infrastructure for advanced computing.[13] Recommendations from goals (1) and (4) led to a new program solicitation in FY 2018, supporting the initial phase of a leadership-class computing facility.
- *Information Technology and the U.S. Workforce: Where Are We and Where Do We Go from Here?:* published a report in 2017 on the interactions between technological, economic, and societal trends, notably how significant advances in IT and automation have profoundly impacted the way work is conducted, and identified open questions and promising research pathways.[14]
- *Growth of Computer Science Undergraduate Enrollments:* published a report in 2017 recommending responses to growing undergraduate computer science enrollments, including: (1) bringing computer science faculty and institutional leaders together to identify best practices and innovation in computer science education across the entire student body; (2) conducting research on how best to use technology in teaching large classes, and on best practices for supporting diversity in computing; and (3) expanding instructional resources for undergraduate computer science education.[15]
- *Envisioning the Data Science Discipline: The Undergraduate Perspective:* published an interim report in 2017 summarizing the initial results toward developing a vision for the emerging discipline of data science at the undergraduate level.[16]

[12] www.nap.edu/catalog/23686/a-21st-century-cyber-physical-systems-education
[13] www.nap.edu/catalog/21886/future-directions-for-nsf-advanced-computing-infrastructure-to-support-us-science-and-engineering-in-2017-2020
[14] www.nap.edu/catalog/24649/information-technology-and-the-us-workforce-where-are-we-and
[15] https://www.nap.edu/catalog/24926/assessing-and-responding-to-the-growth-of-computer-science-undergraduate-enrollments
[16] https://www.nap.edu/catalog/24886/envisioning-the-data-science-discipline-the-undergraduate-perspective-interim-report

OFFICE OF ADVANCED CYBERINFRASTRUCTURE (OAC) **$210,090,000**
-$13,270,000/ -5.9%

OAC Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Total	**$223.36**	**-**	**$210.09**	**-$13.27**	**-5.9%**
Research	**85.80**	**-**	**82.04**	**-3.76**	**-4.4%**
CAREER	1.95	-	1.83	-0.12	-6.2%
Education	**9.41**	**-**	**8.80**	**-0.61**	**-6.5%**
Infrastructure	**128.15**	**-**	**119.25**	**-8.90**	**-6.9%**
Networking and Computational Resources Infrastructure and Services	128.15	-	117.50	-10.65	-8.3%
Research Resources - Public Access Activity	-	-	1.75	1.75	N/A

OAC Summary

OAC supports the exploration, development, deployment, and expert services necessary for world-leading research cyberinfrastructure (CI), which is critical to the advancement of all areas of science and engineering research and education in the 21st century and therefore essential to sustaining U.S. economic competitiveness and national security. In partnership with all NSF directorates and offices as well as other CISE divisions, OAC support to academic institutions encourages a rich and vibrant ecosystem that blends computer and computational research and research-specific cyberinfrastructure with innovations from the private sector. Specifically, OAC investments include acquisition, integration, coordination, and operations associated with shared data, secure networking, advanced computation, scientific software, and the design and development of computational and data-enabled science and engineering tools and expertise. OAC also nurtures the computational and data skills and expertise needed to conduct next-generation science and engineering. To address complex and multidisciplinary discovery, prediction, and innovation, OAC enables more than 8,000 faculty and researchers to access computational resources and services, along with secure connectivity to major international facilities and scientific instruments. Ultimately, OAC promotes secure CI interoperability, sharing, and collaborations among academic research infrastructure groups, other federal agencies and international research funders, and the private sector.

In FY 2017, about 37 percent of the OAC portfolio was available for new grants and 63 percent was available for continuing grants.

In FY 2018, NSF investments in the Public Access Activity were transferred from SBE to OAC. This NSF-wide activity supports efforts to make NSF-funded research available to the public, including developing outreach and guidance materials.

DIVISION OF COMPUTING AND COMMUNICATION FOUNDATIONS (CCF) **$183,030,000**
-$10,540,000/ -5.4%

CCF Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Total	**$193.57**	**-**	**$183.03**	**-$10.54**	**-5.4%**
Research	**182.91**	**-**	**171.18**	**-11.73**	**-6.4%**
CAREER	16.66	-	15.75	-0.91	-5.5%
Centers Funding (total)	8.00	-	6.70	-1.30	-16.3%
STC: Center for the Science of Information	5.00	-	3.70	-1.30	-26.0%
STC: Center for Brains, Minds and Machines: The Science and the Technology of Intelligence	3.00	-	3.00	-	-
Education	**10.06**	**-**	**11.25**	**1.19**	**11.8%**
Infrastructure	**0.60**	**-**	**0.60**	**-**	**-**
National Nanotechnology Coordinated Infrastructure (NNCI)	0.60	-	0.60	-	-

CCF Summary

CCF contributes to scientific advancement, economic growth, human health, and national security by laying the foundations of the theory and practice of computing and communication. CCF supports research and education activities that explore the foundations and limits of computation, communication, and information; advance algorithmic knowledge for research areas within and outside computer science; and advance software and hardware 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 approaches for parallel, distributed, and heterogeneous multi-core machines. CCF invests in research that addresses the theoretical underpinnings and enabling technologies for information acquisition, transmission, and processing in communication and information networks, such as sensor, wireless, multimedia, quantum, and biological networks. CCF investments advance the design, verification, evaluation, and utilization of computing hardware and software through new theories, programming languages, and formal methods that focus on achieving performance, correctness, usability, reliability, and scalability. CCF research explores the potential impact of emerging technologies on computation and communication, including nanotechnology, biotechnology, and quantum devices and systems.

In FY 2017, 72 percent of the CCF portfolio was available for new grants and 28 percent was available for continuing grants.

In FY 2019, CCF support for the STC Center for the Science of Information will ramp down as the center begins its natural sunset.

DIVISION OF COMPUTER AND NETWORK SYSTEMS (CNS) **$217,090,000**
-$14,270,000/ -6.2%

CNS Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Total	**$231.36**	**-**	**$217.09**	**-$14.27**	**-6.2%**
Research	**185.77**	**-**	**176.24**	**-9.53**	**-5.1%**
CAREER	10.89	-	10.22	-0.67	-6.2%
Education	**17.35**	**-**	**13.85**	**-3.50**	**-20.2%**
Infrastructure	**28.24**	**-**	**27.00**	**-1.24**	**-4.4%**
Research Resources	28.24	-	27.00	-1.24	-4.4%

CNS Summary

CNS contributes to scientific advancement, national security, and economic development through research and education activities that advance understanding of the fundamental properties of computer systems and networks. CNS investments produce new insights into the dynamics of complex hardware and software systems, and explore new architectures for future-generation computing and communication infrastructures and services, thereby lowering barriers to innovation and enhancing economic competitiveness. CNS-enabled systems include, but are not limited to, cyber-physical, embedded, distributed, centralized, virtualized, and mobile systems. CNS also provides scientific leadership in cybersecurity, supporting research and education activities to ensure that society's ubiquitous computing and communication infrastructures 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 systems research infrastructure and in the development of the computing workforce of the future.

In FY 2017, 69 percent of the CNS portfolio was available for new grants and 31 percent was available for continuing grants.

In FY 2019, CNS will continue to participate in ADVANCE and NSF INCLUDES, but the funds for these NSF-wide education-related programs will be centrally located in EHR.

DIVISION OF INFORMATION AND INTELLIGENT SYSTEMS (IIS) **$192,070,000**
-$2,510,000/ -1.3%

IIS Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Total	**$194.58**	**-**	**$192.07**	**-$2.51**	**-1.3%**
Research	**184.18**	**-**	**180.82**	**-3.36**	**-1.8%**
CAREER	19.30	-	19.05	-0.25	-1.3%
Centers Funding (total)	1.00	-	1.00	-	-
STC: Center for Brains, Minds and Machines: The Science and the Technology of Intelligence	1.00	-	1.00	-	-
Education	**10.40**	**-**	**11.25**	**0.85**	**8.2%**

IIS Summary

IIS contributes to scientific advancement, economic growth, human health, and national security by studying the interrelated roles of people, computers, and information. IIS supports research and education activities that develop new knowledge about the role of people in the design and use of information technology with the goal of advancing human capabilities. IIS activities also increase our capability to create, manage, and understand data and information in systems ranging from implanted nano-processors to hand-held computers and globally distributed systems. IIS research advances our understanding of how computational systems can exhibit the hallmarks of intelligence through investments in artificial intelligence, computer vision, robotics, machine learning, natural language processing, computational neuroscience, cognitive science, and related areas. These activities lay the foundation for work at the human-technology frontier by improving our understanding of how constantly evolving technologies are actively shaping our lives and how we in turn can shape those technologies, especially in a 21st-century digital society.

In FY 2017, 70 percent of the IIS portfolio was available for new grants and 30 percent was available for continuing grants.

DIVISION OF INFORMATION TECHNOLOGY RESEARCH (ITR) **$123,140,000**
+$30,080,000/ 32.3%

ITR Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Total	**$93.06**	**-**	**$123.14**	**$30.08**	**32.3%**
Research	**78.55**	**-**	**106.19**	**27.64**	**35.2%**
Big Idea: Harnessing the Data Revolution	-	-	30.00	30.00	N/A
CAREER	0.89	-	-	-0.89	-100.0%
Centers Funding (total)	1.00	-	1.00	-	-
STC: Center for Brains, Minds and Machines: The Science and the Technology of Intelligence	1.00	-	1.00	-	-
Education	**2.96**	**-**	**1.95**	**-1.01**	**-34.1%**
Infrastructure	**11.55**	**-**	**15.00**	**3.45**	**29.9%**
Research Resources	11.55	-	15.00	3.45	29.9%

ITR Summary

ITR contributes to scientific advancement, economic growth, human health, and national security by providing support for transformative explorations in computer and information science and engineering research, infrastructure, and education, emphasizing the funding of innovative, high-risk/high-reward, multi-investigator projects.

In FY 2019, CISE, in partnership with all of the NSF research directorates and offices, will advance the HDR Big Idea by investing ITR funds to support convergent activities that transcend the traditional disciplinary boundaries of individual NSF directorates and offices. These activities will enable pursuit of fundamental research in data science and engineering; the development of a cohesive, federated, national-scale approach to research data infrastructure; and the development of a 21st-century data-capable workforce. While budget management and reporting for this ITR investment will be the responsibility of CISE, the convergent activities will be overseen and managed collaboratively by the multi-directorate/office HDR leadership team.

In FY 2017, 57 percent of the ITR portfolio was available for new grants and 43 percent was available for continuing grants.

In FY 2019, ITR will continue to participate in NSF INCLUDES, but the funds for this NSF-wide education-related program will be centrally located in EHR.

APPENDIX A – HIGH-PERFORMANCE COMPUTING PORTFOLIO

High Performance Computing Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request
Petascale Computing	$0.36	-	$32.48
Innovative HPC Program	29.91	-	30.00
Extreme Digital (XD)	56.73	-	2.40
Total	**$87.00**	**-**	**$64.88**

For nearly four decades, NSF has been a recognized leader in enabling the innovative use and broad availability of a cohesive and powerful High-Performance Computing (HPC) ecosystem to accelerate fundamental science and engineering. NSF aims to sustain America's leadership in the research, development, and broad deployment of existing as well as new HPC technologies and skills—and aims to do so in part through leadership of the National Strategic Computing Initiative (NSCI) jointly with the Department of Defense (DOD) and Department of Energy (DOE), and in concert with other participating federal agencies and the private sector. Key NSF foci include fundamental discoveries to support future generations of advanced computing; research and cyberinfrastructure promoting cohesive platforms and interoperability for large-scale data analytics as well as modeling and simulation; and support for a comprehensive advanced computing ecosystem for science and engineering research. These foci include an emphasis on a holistic approach to America's science and engineering computational infrastructure, spanning both human and technical dimensions.

The overall NSF HPC strategy and program portfolio receives guidance and input from the Advisory Committee for Cyberinfrastructure (ACCI); Assistant Directors (AD) Council, which includes ADs and Office Heads from the various NSF research directorates and offices; and cross-directorate working group for NSCI. In 2013, OAC supported a two-year National Academies' study to further inform the implementation of its HPC strategy in the 2017 to 2020 timeframe; the final report, *Future Directions for NSF Advanced Computing Infrastructure to Support U.S. Science and Engineering in 2017-2020*, was published in 2016.[17] In 2017, OAC funded a study of best practices for collaborations between academic or federally-funded HPC centers and industry.

Leadership-Class Computing

Description

A key and integrated component of NSF's current HPC ecosystem investment is its support of a leadership-class HPC resource called Blue Waters. As one of the most powerful supercomputers in the world and one of the fastest supercomputers deployed on a university campus, Blue Waters is based at the National Center for Supercomputing Applications (NCSA) at the University of Illinois at Urbana-Champaign (UIUC). The Blue Waters system became 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.

Since becoming operational in FY 2013, Blue Waters has allowed researchers to tackle much larger and more complex research challenges than ever before possible across and within disciplines as diverse as biology, astronomy, engineering, materials science, and the geosciences. Examples of transformational

[17] www.nap.edu/catalog/21886/future-directions-for-nsf-advanced-computing-infrastructure-to-support-us-science-6

research enabled by Blue Waters include: biophysicist Klaus Schulten and his team at UIUC used experimental data combined with simulations on Blue Waters to discover the precise chemical structure of the hard-shell capsid encasing the HIV virus (with funding from NIH);[18] a public-private collaboration among multiple federal agencies, universities, and companies brought together data, expertise, and the unique capabilities of Blue Waters to create the first-ever publicly-available, high-resolution elevation maps of the Arctic;[19] and ExxonMobil geoscientists and NCSA demonstrated a massive parallel reservoir simulation that ran thousands of times faster than typical oil and gas industry reservoir simulations, in turn allowing faster, more cost-effective, and environmentally-responsible decisions.[20]

The broader impacts of Blue Waters include provisioning unique infrastructure for research and education; extensive efforts accelerating education and training in the use of HPC in science and engineering; 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 and engineering, in part through NCSA's Girls Engaged in Mathematics and Science (GEMS) program, which is designed to encourage middle-school girls to consider mathematics- and science-oriented careers.

Current Status

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. The acquisition and deployment award provided support for the first six months of operations. A separate award to UIUC in FY 2013 provided support for the remaining operational phase, from FY 2014 through mid-FY 2018. This award was granted a no-cost extension in FY 2016 that runs through mid-FY 2019.

Education and outreach projects are ongoing; they target pre-college, undergraduate, graduate, and post-graduate students. The Blue Waters project also sponsors workshops, conferences, summer schools, and seminars. The project includes industry partnership activities as well. The Industry Partners in Petascale Engagement (IPIPE) program provides industry partners across a wide range of market sectors (e.g., health, energy, advanced manufacturing) with expertise as well as a first look at the technological and scientific developments that flow from the petascale program.

Despite the success of the Blue Waters supercomputer, the system is reaching its natural obsolescence, and will complete its operational cycle in March 2019, when the no-cost extension for the operations and maintenance award ends. With the extension of the operational end date of Blue Waters to 2019, the system will have run for roughly two years longer than the typical lifetime for a system of this type.

In anticipation of the operational end date of Blue Waters, in FY 2017, NSF issued a competitive solicitation[21] for the first phase (Phase 1) of a two-phase plan to deploy a new leadership-class HPC system. The Phase 1 system is expected to be two to three times more powerful in application performance than Blue Waters. In FY 2018, NSF expects to award approximately $60 million for the system acquisition. The operations and maintenance phase of the leadership HPC system is expected to commence in FY 2019 and last for five years under a separate award. When fully deployed, the Phase 1 system is expected to broadly extend new large-scale HPC benefits across the academic landscape, including support for previously unattainable research advances in large-scale modeling and simulation; use of robust data analytics at unprecedented scales for research; and use of HPC in dynamic workflows combining large-scale computation with big data streaming. In addition to the operations and maintenance award, a related

[18]https://news.illinois.edu/blog/view/6367/204804
[19]http://nga.maps.arcgis.com/apps/MapSeries/index.html?appid=cf2fba21df7540fb981f8836f2a97e25
[20]www.ncsa.illinois.edu/news/story/exxonmobil_sets_record_on_ncsas_blue_waters_supercomputer
[21]www.nsf.gov/pubs/2017/nsf17558/nsf17558.htm

FY 2019 award to the Phase 1 awardee is anticipated to fund a Conceptual Design in anticipation of a future Major Research Equipment and Facilities Construction for Phase 2 of the leadership-class HPC system.

The continuing investments in the HPC program are guided by input from many stakeholder groups. These include the ACCI; AD Council; NSF program staff spanning the Foundation's research directorates and offices; the cross-directorate NSCI working group; and the National Academies' study section mentioned above. Additionally, international activities to accelerate investments in leadership-class computing, particularly in Europe and Asia, are providing additional urgency and importance for this investment strategy to maintain the Nation's global leadership role in science and engineering.

Science and engineering research and education activities enabled by Blue Waters

Blue Waters is enabling investigators across the country to conduct innovative research not otherwise possible due to demanding technical requirements. Over its lifetime, the Blue Waters project has enabled more than 700 project teams, with the largest allocation awards made through the highly competitive NSF Petascale Computing Resource Allocations (PRAC) program. The research topics the PRAC program supports include: complex biological behavior in fluctuating environments; electronic properties of strongly correlated systems; properties of hydrogen and hydrogen-helium mixtures in astrophysically-relevant conditions; electronic and magnetic structures of transition metal compounds; molecular dynamics responsible for the properties of liquid water; and propagation of seismic energy through a detailed structural model of Southern California together with prediction of ground motion and 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; 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.

To date, there have been more than 200 education, outreach, and training projects engaging over 3,700 individuals at over 160 institutions, including 41 institutions in Established Program to Stimulate Competitive Research (EPSCoR) jurisdictions and 14 Minority-Serving Institutions.

Management and Oversight

The Blue Waters project is overseen by OAC's program directors and NSF Division of Grants and Agreement (DGA) staff who receive strategic advice from the AD Council. Advice from the NSF Office of General Counsel (OGC) is also sought as necessary.

The National Science Board (NSB) receives 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.

The plan for a phased approach to support a next-generation, leadership-class HPC system was discussed with the NSB in advance of the issuance of the FY 2017 solicitation.

Innovative HPC Program

Description

The Innovative HPC program funds nationally-available HPC capabilities that, in aggregate, are technically diverse, reflecting changing and growing use of data-intensive computation in both the research and education processes. At the same time, they are intended to enable discoveries at a computational scale beyond the reach of an individual or regional academic institution.

There is a direct relationship between the Innovative HPC program and the eXtreme Digital (XD) program, as described below. Deployed systems serve as a cohesive set of allocable resources within the XD

integrated services infrastructure. Innovative HPC awards are generally made as two parts: an acquisition/development and deployment award that may be the result of a competitive or a renewal proposal; and a separate award for operations and maintenance following deployment. When an award is made, the awardee institution issues sub-awards to vendors and/or other organizations for acquisitions and services as necessary. Expenditures are contingent on successful completion of deployment milestones.

Beginning with the FY 2011 Innovative HPC program solicitation, *High Performance System Acquisition: Enhancing the Petascale Computing Environment for Science and Engineering*,[22] a more sustained approach for the largest HPC services was initiated in response to community input. This approach recognizes the value and sustained institutional commitment required for building and retaining staff skilled in interdisciplinary computational and data science by allowing, at the discretion of NSF, a longer time horizon of eight to 10 years for a single institutional awardee. This timeline begins with a competitively awarded acquisition but allows for the possibility of a renewal acquisition award four years after the original award. In addition to the acquisition awards, there are accompanying operations and maintenance awards following deployment.

Current Status

Four additional resources, Comet, Bridges, Jetstream, and Wrangler, commenced operations in FY 2015 and FY 2016. In FY 2017, Stampede 2, the largest of the currently active Innovative HPC resources, commenced operation.

Deployed in FY 2015, Wrangler is the most powerful data analysis system allocated in XD, with 10 petabytes (PB) of replicated, secure, high-performance data storage. This innovative system consists 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). Wrangler provides flexible support for a wide range of software stacks, including Hadoop and relational data. Support for ongoing Wrangler operations and maintenance is provided to the University of Texas at Austin through FY 2020 at a level of approximately 20 percent of the initial acquisition cost per annum, consistent with the level specified in the FY 2013 Innovative HPC program solicitation.[23]

Comet also came online in FY 2015 at the University of California, San Diego. It supports research interests and priorities requiring large, high-throughput workloads, which in turn prompt massive amounts of computation but at moderate scalability. Notably, as a resource responsive to the "long tail of science," Comet is particularly well-suited for the large-scale computational needs of research community portals such as Cyberinfrastructure for Phylogenetic Research as well as distributed workflows such as those required by the Laser Interferometer Gravitational-Wave Observatory. Comet's heterogeneous configuration supports not only complex simulations but also advanced analytics and visualization of outputs. As a result of its role in machine learning, visualization, and advanced analytics, supplemental funding was provided to increase the graphics processing units component of Comet in FY 2017. Comet is also planned to remain operational through FY 2020.

Bridges came online in FY 2016 at the Pittsburgh Supercomputing Center on the campus of Carnegie Mellon University. Bridges provides an innovative and groundbreaking HPC and data analytics system integrating advanced memory technologies to empower new communities. It brings desktop convenience to HPC, connecting to campuses, and intuitively integrating data-intensive workflows to increase the scientific output of a large community of scientific and engineering researchers that has not traditionally used HPC resources. Bridges extends HPC's impact to EPSCoR jurisdictions and Minority-Serving

[22] www.nsf.gov/pubs/2011/nsf11511/nsf11511.htm
[23] www.nsf.gov/pubs/2013/nsf13528/nsf13528.htm

Institutions, raising the level of computational awareness at four-year colleges, and promoting computational thinking in high-schools.

Jetstream also came online in FY 2016 at Indiana University. Jetstream is a cloud-based platform that incorporates the best elements of commercial cloud computing resources with some of the best software for solving important scientific problems. Jetstream enables new modes of sharing data and computational analysis, allowing for increased scientific reproducibility and enabling American scientists and engineers to make new discoveries that are important to understanding the world around us, thereby improving the quality of life for all Americans and promoting America's competitive standing in the world.

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 continued to operate through December 2017. The resources and accompanying services targeted science and engineering researchers using both advanced computational methods and emerging data-intensive approaches. The system boosted XD resources to nearly twice their previous capacity and provided researchers with early access to Intel Many Integrated Core processors, which were accepted in August 2013. It operated as the "backbone" for the XD environment, enabling more than 5,000 researchers and annually supporting more than 1,000 computationally intensive research projects across the Nation.

In FY 2016, NSF awarded *Stampede2: The Next Generation of Petascale Computing for Science and Engineering* to the University of Texas at Austin following a rigorous merit review, enabling the acquisition, development, and deployment of "Stampede2" as a successor resource to Stampede. When fully operational, Stampede2 will serve as the primary national resource (i.e., the "workhorse") for thousands of American academic researchers, complement other national HPC resources, and provide capabilities beyond the reach of individual campuses and regional resources, including support for multiscale modeling, simulation, and data-intensive research. Stampede2 is being deployed into production operation through three phases: Knights Landing many-core nodes are already deployed, demonstrating increased performance at lower power rates; the highly complementary SkyLake processors, which are responsive to data-intensive computing, are in early operations and will fully deploy as a peak 18-petaflop system in FY 2018; and the final deployment phase, also in FY 2018, will introduce persistent memory to the previously-deployed Skylake processors to significantly enhance overall system performance. Stampede2 will serve the high-end, open science community through FY 2021.

Science and engineering research and education activities enabled by Innovative HPC

Innovative HPC is enabling new, world-leading, and transformative advances across the breadth of science and engineering research, in the integration of research and education, and in broadening participation in science and engineering by underrepresented groups. It is enabling new collaborations across public and private sectors to advance American security and economic competitiveness. These advances are enabled by providing researchers and educators with usable access to world-leading computational resources, expertise, and services beyond those typically available on most campuses, including the interfaces, consulting support, and training necessary to facilitate their use. This program is central to America achieving the full potential of complementary investments by NSF, other federal agencies, and academic institutions.

Management and Oversight

OAC's program directors provide direct oversight during both the acquisition as well as operations and maintenance awards. Formal reporting consists of quarterly and annual reports, which are reviewed by the program directors.

Each Innovative HPC program award is managed under a cooperative agreement. Each awardee is responsible for the satisfactory completion of milestones prior to NSF authorization of spending. Progress

is assessed with the aid of annual external reviews. Each project has a project management plan. Each cooperative agreement includes the management structure, milestones, spending authorization levels, and review schedule.

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 risks that should be considered. 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. Typically, project risks are substantially reduced subsequent to deployment. Thus, pacing of acquisitions and deployments allows balance in overall portfolio risk for the Innovative HPC program.

Milestone-driven reviews occur during the acquisition award, typically with an external review prior to deployment. Annual reviews, conducted by an external panel of expert reviewers and managed by OAC program directors, are performed during the operational phase of each project.

Extreme Digital (XD) Program

Description

The XD program adds value to the Innovative HPC program by coordinating the HPC resources and services, providing advanced assistance to the user community, and broadening participation. The XD program's shared services model for coherently and efficiently delivering to researchers both access and expertise to diverse, dynamic, and distributed resources is a cornerstone of America's HPC ecosystem. Enabling the connection between individual campuses and national resources is an essential aspect of the HPC ecosystem.

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, while ensuring that the infrastructure continues to deliver high-quality access for the many researchers and educators who use it in their work.

XD shared services consist of several interrelated parts: allocation of resources to computational and data research projects; advanced user assistance; training, education, and outreach; architecture and operation of an integrated digital services infrastructure; metrics services; and overall coordination. The XD Metrics Service (XMS) is a separate award, while all other services constitute the eXtreme Science and Engineering Discovery Environment (XSEDE) project. These elements are designed and implemented in a way that is clearly tied to the requirements of the science and engineering research community, using a flexible methodology that permits the architecture to evolve in response to changing community needs and that presents individual users with a common environment regardless of where the resources or researchers are located.

Current Status

Two awards are currently active within the XD program: XSEDE and XMS. The smaller XMS award was made in FY 2015 to the University at Buffalo – The State University of New York. This award provides metrics services allowing measurement of key operational data for both resources and services. The XSEDE award to UIUC was renewed in September 2016, continuing the prior XSEDE award for another five-year period. There are 18 XSEDE partners engaged via subawards to the University of Tennessee at Knoxville (National Institute for Computational Sciences), Carnegie Mellon University and University of Pittsburgh (Pittsburgh Supercomputing Center), University of Texas at Austin (Texas Advanced Computing Center), University of California, San Diego (San Diego Supercomputing Center), University of Chicago, Indiana

University, Purdue University, Shodor Education Foundation, Ohio Supercomputer Center, Southeastern Universities Research Association, Cornell University, National Center for Atmospheric Research (NCAR), Georgia Institute of Technology, Oklahoma State University, University of Georgia, Oklahoma University, University of Southern California, and University of Arkansas. XSEDE has annual external reviews at NSF. The first external review of the renewed project took place in June 2017.

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 underrepresented groups. These advances are 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 HPC services; and enables researchers to efficiently manipulate, analyze, visualize, and share extremely large amounts of distributed digital information from simulations, sensors, and experiments.

XD's XSEDE project delivers 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 dynamic 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, thereby promoting enhanced productivity.

XD's XMS project develops analysis tools and collects operational data from XD projects such as XSEDE and the Innovative HPC resources. The immediate users of these methods and tools are the providers of NSF-supported HPC resources and services. However, both tools and data are publicly available and used by other projects such as Blue Waters and individual universities.

Management and Oversight

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

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.

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.

Annual reviews for XSEDE and mid-project reviews for XMS are conducted by external panels of expert reviewers and managed by OAC program directors.

DIRECTORATE FOR ENGINEERING (ENG) **$921,430,000**
-$9,490,000 / -1.0%

ENG Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Percent
Chemical, Bioengineering, Environmental and Transport Systems (CBET)	$183.54	-	$180.00	-$3.54	-1.9%
Civil, Mechanical, and Manufacturing Innovation (CMMI)	221.05	-	216.90	-4.15	-1.9%
Electrical, Communications, and Cyber Systems (ECCS)	113.78	-	111.60	-2.18	-1.9%
Engineering Education and Centers (EEC)	108.61	-	97.25	-11.36	-10.5%
Industrial Innovation and Partnerships (IIP)	250.26	-	248.42	-1.84	-0.7%
Emerging Frontiers and Multidisciplinary Activities (EFMA)	53.67	-	67.26	13.59	25.3%
Total	**$930.92**	**-**	**$921.43**	**-$9.49**	**-1.0%**

About ENG

Fundamental research supported by ENG, combined with the creativity of well-educated engineers and the resources of state-of-the-art facilities, has resulted in many important discoveries. These discoveries have fueled exciting technological innovations—such as nanotechnology-enabled consumer, industrial, and healthcare products and manufacturing; resilient infrastructure to withstand disaster and disruption; novel light-based devices and tools for brain-related research and neurological imaging; secure, efficient devices and systems for communications and computing; and Internet-enabled smart manufacturing systems and supply chains—that in turn have stimulated economic growth and are improving the quality of life for all Americans.

ENG funding of disciplinary and multidisciplinary research lays the groundwork for crucial aspects of NSF's 10 Big Ideas. ENG investments contribute to Harnessing the Data Revolution through, for example, support for cyber–physical systems, smart and connected communities, spectrum efficiency and sharing, and devices and systems for the Internet of Things. The directorate creates a foundation for Quantum Leap through support for topics such as quantum sensing, communication and computing research, and investment in quantum technologies for secure communication systems. ENG investment supports the Future of Work at the Human–Technology Frontier through research in robotics, smart materials, control and communication systems, and other areas. ENG supports Understanding the Rules of Life by investing in nanotechnologies that help reveal life's fundamental processes, biomechanics and tissue engineering, and new methods for engineering biology. ENG investments contribute to Navigating the New Arctic through research in water supply and treatment, sustainability, advanced materials, and resilient infrastructure. The directorate is a committed partner to NSF INCLUDES and provides critical leadership for engineering communities. ENG has made a special contribution to Growing Convergence Research by originating the concept of convergence nearly 15 years ago as an outgrowth of the National Nanotechnology Initiative.

ENG provides about 43 percent of federal funding for basic research at academic institutions in the engineering sciences.

Major Investments

ENG Major Investments
(Dollars in Millions)

Area of Investment	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
CAREER	$78.00	-	$76.00	-$2.00	-2.6%
CEMMSS[1]	110.00	-	-	-110.00	-100.0%
INFEWS	9.70	-	5.00	-4.70	-48.5%
IUSE	4.97	-	5.00	0.03	0.5%
NSF I-Corps™	12.91	-	13.00	0.09	0.7%
NSF Research Traineeship[2]	2.50	-	-	-2.50	-100.0%
Risk and Resilience[3]	9.12	-	-	-9.12	-100.0%
SaTC	3.25	-	3.25	-	-
Understanding the Brain	23.40	-	16.75	-6.65	-28.4%
BRAIN Initiative	*23.40*	*-*	*16.75*	*-6.65*	*-28.4%*
NSF's Big Ideas					
The Future of Work at the Human-Technology Frontier	*-*	*-*	*30.00*	*30.00*	*N/A*
NSF INCLUDES[4]	*1.20*	*-*	*-*	*-1.20*	*-100.0%*

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

[1]The CEMMSS program sunsets in FY 2019.

[2]In FY 2019, NRT funding is provided through CISE and EHR.

[3]Risk and Resilience topics will continue to be funded through ENG core programs in FY 2019.

[4]In FY 2019, NSF INCLUDES funding is provided through the EHR account.

ENG Funding for Centers Programs and Facilities

ENG Funding for Centers Programs
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Total	**$72.36**	**-**	**$68.40**	**-$3.96**	**-5.5%**
Engineering Research Centers (EEC)	57.49	-	56.00	-1.49	-2.6%
STC: Emergent Behaviors for Integrated Cellular Systems (CBET)	5.00	-	3.70	-1.30	-26.0%
STC: Engineering Mechano-Biology (CMMI)	4.87	-	5.00	0.13	2.6%
STC: Energy Efficient Electronics Science (ECCS)	5.00	-	3.70	-1.30	-26.0%

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

ENG Funding for Facilities

(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Total	**$25.91**	**-**	**$22.58**	**-$3.33**	**-12.8%**
Cornell High Energy Synchrotron Source (CHESS)	5.00	-	-	-5.00	-100.0%
National Nanotechnology Coordinated Infrastructure (NNCI)	10.92	-	10.83	-0.09	-0.8%
Natural Hazards Engineering Research Infrastructure (NHERI)	14.99	-	11.75	-3.24	-21.6%

For detailed information on individual facilities, please see the Facilities and the Major Research Equipment and Facilities Construction chapters.

Funding Profile

ENG Funding Profile

	FY 2017 Actual Estimate	FY 2018 (TBD)	FY 2019 Estimate
Statistics for Competitive Awards:			
Number of Proposals	13,028	-	13,200
Number of New Awards	2,455	-	2,400
Funding Rate	19%	-	18%
Statistics for Research Grants:			
Number of Research Grant Proposals	9,753	-	9,900
Number of Research Grants	1,801	-	1,700
Funding Rate	18%	-	17%
Median Annualized Award Size	$106,667	-	$108,000
Average Annualized Award Size	$125,140	-	$127,000
Average Award Duration, in years	2.7	-	2.7

People Involved in ENG Activities

Number of People Involved in ENG Activities

	FY 2017 Actual Estimate	FY 2018 (TBD)	FY 2019 Estimate
Senior Researchers	8,811	-	8,600
Other Professionals	2,067	-	2,000
Postdoctoral Associates	527	-	500
Graduate Students	7,607	-	7,500
Undergraduate Students	4,510	-	4,400
K-12 Teachers	-	-	-
K-12 Students	-	-	-
Total Number of People	**23,522**	**-**	**23,000**

Program Monitoring and Evaluation

External Program Evaluations and Studies

- The ERC program periodically commissions program-level evaluations by external evaluators to determine the effectiveness of ERC graduates in industry, the benefits of ERC membership to industry and others. In FY 2015, NSF funded the National Academies of Science, Engineering, and Medicine (the National Academies) to study The Future of Center-Based, Multidisciplinary Engineering Research. This topic arose from discussions the National Academies held on the future of NSF's center-based, multidisciplinary engineering research. To help inform the study, the National Academies held a public symposium on April 6, 2016, and published a proceedings.[1] The study report,[2] delivered May 2, 2017, articulates a vision for the future of NSF-supported center-scale, multidisciplinary engineering research, which ENG is carefully analyzing for the path ahead. A new solicitation for the next generation of ERCs is expected in FY 2018.
- A study of the feasibility of performing rigorous impact evaluation of the I-Corps™ Teams program was completed in FY 2014. Based on the feasibility study, NSF initiated a rigorous evaluation of the I-Corps™ Teams program in FY 2016. A report will be available in FY 2018.
- During FY 2017, ENG developed an evaluation framework that identifies outcomes to be monitored across directorate programs. The framework, developed by participants from all ENG divisions, has four areas of activity: (1) research, (2) human capital development and partnerships, (3) centers and networks, and (4) construction of physical, virtual, and cyberinfrastructure. The directorate expects to use this framework to develop an outcome monitoring system for all programs using internal Research Performance Progress Report (RPPR) data, external data sets (patents and bibliometric data), and potentially a common survey. The design of this evaluation framework eliminates the need for individual longitudinal outcome monitoring systems (e.g., for the Emerging Frontiers in Research and Innovation program).
- In FY 2016, IIP collected data for the PFI: Accelerating Innovation Research (AIR) and PFI: Building Innovation Capacity (BIC) programs based on their theories of action. In FY 2017, ENG finalized a report for the longitudinal outcomes of the PFI: AIR program to date. A report for the PFI: BIC program is being finalized. The PFI program was restructured, and the FY 2018 PFI solicitation reflects the changes.

Workshops and Reports

- In FY 2017, to further open pathways into engineering, EEC provided support for "A Workshop to Finalize the Planning for a National Pilot of an advanced placement course in Engineering," held at the University of Maryland College Park, October 12-13, 2017. The three workshop goals were to review and revise the draft curriculum framework for the AP in Engineering course; define the role organizations play in the pilot; and develop training objectives for the pilot teachers. In FY 2018, EEC will continue working with partner universities and high schools to refine and gain approval for the AP curriculum and professional development program for teachers, in preparation for pilot activities.
- In FY 2017, ENG (CBET and EFMA) and BIO co-funded a workshop on "The Subterranean Macroscope: Sensor networks for understanding, modeling, and managing soil processes," held November 1-2, 2017, at the University of Chicago. The workshop goal was to create a vision and framework for how such a subterranean sensor network could be built across different geographical scales, with sensors that will generate dense, useful data that will inform soil science, plant science, and modeling efforts. These efforts, in turn, would lead to the next level of understanding of the physical, chemical, and biological nature of soil and its impact on plant science and food security. The workshop

[1]A Vision for the Future of Center-Based Multidisciplinary Engineering Research symposium proceedings: www.nap.edu/catalog/23645/a-vision-for-the-future-of-center-based-multidisciplinary-engineering-research

[2]A New Vision for Center-Based Engineering Research report: www.nap.edu/catalog/24767/a-new-vision-for-center-based-engineering-research

included diverse scientists and engineers and representatives from industry and the small business community. The workshop is expected to generate cross-directorate research opportunities advancing measurement system capabilities for soil biological, chemical, and physical components over space and time and to contribute to several of NSF's 10 Big Ideas.

- In FY 2017, CMMI supported a workshop on "Disrupting Illicit Supply Networks: New Applications of Operations Research and Data Analytics to End Modern Slavery," held in Washington, D.C., on December 1-2, 2017. The workshop brought together operations researchers, computer scientists, social scientists, business researchers, geographers, social service agency representatives, and federal agencies to increase understanding of both the nature, and the challenges to disruption, of illicit supply chains. This is informing creation of a potential research initiative within the CMMI Operations Engineering program.
- In FY 2016, CBET, EFMA and others co-funded a three-year study on Grand Challenges in Environmental Engineering by the National Academies.[3] The study will identify high-priority challenges for environmental engineering and science for the next several decades. The three planned public workshops associated with the study were held May 4-5, 2017; September 5, 2017; and January 11, 2018. The report, expected in FY 2018, will shape the growth of university departments, inspire the next generation of engineers and scientists to address the most pressing global environmental challenges, and improve the training of environmental engineers and scientists to better meet these challenges. It will also help inform NSF program directors of emerging areas for research.
- In FY 2016, CBET funded a workshop on Challenges and Solutions for Integrated Management of Environmental, Health, and Community Impact Data Pertaining to the Oil and Gas Industry that was held in Arlington, Va., during March 7-8, 2016. Such a framework must integrate heterogeneous, structured and unstructured data into an inter-operable and explorable system, one that can be re-purposed by researchers and other stakeholders in order to transfer knowledge between industry, land-use managers, government officials, and the general public. The workshop and its 2017 report[4] have provided insights to NSF in numerous research domains and for efforts in data and cyberinfrastructure as well as the NSF Big Idea on Harnessing the Data Revolution for 21st Century Science and Engineering.
- In FY 2015, EFMA funded the Exploring Innovation Frontiers Initiative (EIFI), a two-year, national public-private effort to shape and strengthen future U.S. innovation and competitiveness led by the Council on Competitiveness. Diverse leaders from academia, industry, and government have participated in a series of regional dialogues during 2015-2016: at the Georgia Institute of Technology on June 9, 2015; the University of California Riverside on November 23, 2015, and at Texas A&M University on November 15, 2016. A fourth and final regional dialogue was held in June 2017 at Washington University in St. Louis. Summaries of the EIFI workshops and the final report[5], published in 2017, will help inform NSF and the community of actionable, interdisciplinary frameworks for next-generation business and research innovation models.

Committees of Visitors (COVs)

- In 2017, no COV meetings were held.
- In 2018, COVs will review ECCS and EFMA.
- In 2019, COVs will review CBET and CMMI.

The Performance chapter provides details regarding the periodic reviews of programs and portfolios of

[3]Grand Challenges in Environmental Engineering project site: www8.nationalacademies.org/cp/projectview.aspx?key=49849
[4]Challenges and Solutions for Integrated Management of Environmental, Health, and Community Impact Data Pertaining to the Oil and Gas Industry report: https://data.airwatergas.org/workshop/files/comfy/cms/files/19/files/original/Data_Workshop_Report_2016-12-28.pdf
[5]Transform: A New Agenda to Boost U.S. Innovation-Driven Competitiveness in the 21st Century report: www.compete.org/storage/reports/transform.pdf

programs by external Committees of Visitors and directorate Advisory Committees. See this chapter for additional information.

DIVISION OF CHEMICAL, BIOENGINEERING, ENVIRONMENTAL, AND TRANSPORT SYSTEMS (CBET) **$180,000,000**
-$3,540,000 / -1.9%

CBET Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Percent
Total	**$183.54**	**-**	**$180.00**	**-$3.54**	**-1.9%**
Research	**177.47**	**-**	**174.16**	**-3.31**	**-1.9%**
CAREER	37.62	-	36.00	-1.62	-4.3%
Centers Funding (total)	5.00	-	3.70	-1.30	-26.0%
STC: Emergent Behaviors for Integrated Cellular Systems	5.00	-	3.70	-1.30	-26.0%
Education	**2.39**	**-**	**2.15**	**-0.24**	**-10.1%**
Infrastructure	**3.68**	**-**	**3.69**	**0.01**	**0.3%**
NNCI	3.68	-	3.69	0.01	0.3%

CBET Summary

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, biomanufacturing, 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 workforce development of major U.S. economy components, such as 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 (transport), and civil (environmental) engineering disciplines. To serve these communities and achieve its goals, CBET is organized into four thematic clusters: Chemical Process Systems; Engineering Biology and Health; Environmental Engineering and Sustainability; and Transport Phenomena.

In general, 81 percent of the CBET portfolio is comprised of new research grants, and 19 percent supports continuing grants.

DIVISION OF CIVIL, MECHANICAL, AND MANUFACTURING INNOVATION (CMMI) **$216,900,000**
-$4,150,000 / -1.9%

CMMI Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Percent
Total	**$221.05**	**-**	**$216.90**	**-$4.15**	**-1.9%**
Research	**200.50**	**-**	**200.55**	**0.05**	**0.0%**
CAREER	22.91	-	25.00	2.09	9.1%
Centers Funding (total)	5.05	-	5.00	-0.05	-1.0%
Engineering Research Centers	0.18	-	-	-0.18	-100.0%
STC: Mechano-Biology	4.87	-	5.00	0.13	2.6%
Education	**3.67**	**-**	**2.70**	**-0.97**	**-26.4%**
Infrastructure	**16.89**	**-**	**13.65**	**-3.24**	**-19.2%**
NHERI	14.99	-	11.75	-3.24	-21.6%
NNCI	1.90	-	1.90	-	-

CMMI Summary

CMMI funds fundamental research in support of the Foundation's strategic goals directed at advances in 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 discoveries enabled by 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 engineered systems; enhance the sustainability and resilience of U.S. infrastructure (for example, buildings, transportation, and communication networks); help protect the Nation from extreme natural and human-induced events; and apply engineering principles to improve the Nation's service and manufacturing enterprise systems, such as healthcare.

In general, 82 percent of the CMMI portfolio is comprised of new research grants and 18 percent supports continuing grants.

DIVISION OF ELECTRICAL, COMMUNICATIONS, AND CYBER SYSTEMS (ECCS) **$111,600,000**
-$2,180,000 / -1.9%

ECCS Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Percent
Total	**$113.78**	**-**	**$111.60**	**-$2.18**	**-1.9%**
Research	**107.06**	**-**	**104.66**	**-2.40**	**-2.2%**
CAREER	15.74	-	15.00	-0.74	-4.7%
Centers Funding (total)	5.00	-	3.70	-1.30	-26.0%
STC: Energy Efficient Electronics Science	5.00	-	3.70	-1.30	-26.0%
Education	**1.38**	**-**	**1.70**	**0.32**	**22.9%**
Infrastructure	**5.34**	**-**	**5.24**	**-0.10**	**-1.9%**
NNCI	5.34	-	5.24	-0.10	-1.9%

ECCS Summary

ECCS addresses fundamental research issues underlying electronic and photonic devices and component technologies (such as bioelectronic, flexible, and quantum devices), power, controls, computation, networking, communications (such as secure, efficient spectrum utilization for wireless), and cyber technologies. The division supports the integration and networking of intelligent systems principles at the nano, micro, and macro scales for applications in: healthcare, security, disaster mitigation, energy, telecommunications, transportation, robotics, 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 future generations of innovative devices and systems.

In general, 80 percent of the ECCS portfolio is comprised of new research grants and 20 percent supports continuing grants.

DIVISION OF ENGINEERING EDUCATION AND CENTERS (EEC) **$97,250,000**
-$11,360,000 / -10.5%

EEC Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Percent
Total	**$108.61**	**-**	**$97.25**	**-$11.36**	**-10.5%**
Research	**85.60**	**-**	**80.15**	**-5.45**	**-6.4%**
CAREER	1.73	-	-	-1.73	-100.0%
Centers Funding (total)	57.15	-	56.00	-1.15	-2.0%
Engineering Research Centers	57.15	-	56.00	-1.15	-2.0%
Education	**23.01**	**-**	**17.10**	**-5.91**	**-25.7%**

EEC Summary

EEC integrates disciplinary basic research and education conducted in other ENG divisions 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/life sciences and engineering, from nanostructured materials to new device concepts, subsystems, and systems. Applications range across a wide spectrum, such as energy, medicine, telecommunications, nanoelectronics, manufacturing, civil infrastructure, the environment, computer networks, cybersecurity, and others. Also included are formal scholarly studies in the professional formation of engineers, which can lead to innovations in engineering education and career development.

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—such as part-time, delayed enrollment, veteran, and others—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 four categories: (1) Major Centers and Facilities; (2) Engineering Education Research; (3) Engineering Workforce Development; and (4) Broadening Participation in Engineering. The Major Centers and Facilities category is comprised of the signature Engineering Research Centers (ERC) program. The ERC program provides the framework for interdisciplinary research and education, development, and technology transfer in partnership with academia, industry, and government. Engineering Education Research 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. Engineering Workforce Development includes programs such as REU and Research Experiences for Teachers (RET). Broadening Participation in Engineering supports research and activities that enhance opportunities for underrepresented groups by addressing structural inequalities and biases within educational and workforce systems. This category also includes EEC's engagement with the NSF INCLUDES initiative, which integrates the agency's investments to build on and scale up what works in broadening participation programs.

In general, 28 percent of the EEC portfolio is comprised of new research grants. The remaining 72 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.

DIVISION OF INDUSTRIAL INNOVATION AND PARTNERSHIPS (IIP) **$248,420,000**
-$1,840,000 / -0.7%

IIP Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Total	**$250.26**	**-**	**$248.42**	**-$1.84**	**-0.7%**
Research	**249.74**	**-**	**248.02**	**-1.72**	**-0.7%**
SBIR/STTR	199.05	-	198.57	-0.48	-0.2%
Education	**0.52**	**-**	**0.40**	**-0.12**	**-23.5%**

IIP Summary

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 hi-tech entrepreneurs and innovators.

IIP is home to two cross-agency small business research programs, the SBIR program and the STTR program. These programs seek to transform scientific discovery into societal and economic benefit by catalyzing private sector commercialization of technological innovations. SBIR/STTR programs provide the opportunity for startups and small businesses to undertake cutting-edge, high-quality scientific research and development with the goal of achieving technology commercialization and enabling new products, processes, or services. SBIR/STTR technology topics draw upon the breadth of NSF scientific and engineering research disciplines and are aligned with national and societal priorities.

IIP also supports academic research through three research programs: IUCRCs, PFI, and GOALI. 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.

IIP also leads the I-Corps™ program that 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, 97 percent of the IIP portfolio is comprised of new research grants and 3 percent supports continuing grants.

OFFICE OF EMERGING FRONTIERS AND MULTIDISCIPLINARY ACTIVITIES (EFMA) **$67,260,000**
+$13,590,000 / 25.3%

EFMA Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Total	**$53.67**	**-**	**$67.26**	**$13.59**	**25.3%**
Research	**44.67**	**-**	**67.16**	**22.49**	**50.4%**
Big Idea: The Future of Work at the Human-Technology Frontier	-	-	30.00	30.00	N/A
Centers Funding (total)	0.16	-	-	-0.16	-100.0%
Engineering Research Centers	0.16	-	-	-0.16	-100.0%
Education	**4.01**	**-**	**0.10**	**-3.91**	**-97.5%**
Infrastructure	**5.00**	**-**	**-**	**-5.00**	**-100.0%**
CHESS	5.00	-	-	-5.00	-100.0%

EFMA Summary

EFMA strategically pursues and funds projects in important emerging areas in a timely manner. The office provides support to multidisciplinary research and is responsible for the financial stewardship of new investments in The Future of Work at the Human Technology Frontier (FW-HTF) Big Idea. The largest activity in EFMA is the Emerging Frontiers in Research and Innovation (EFRI) program.

Each year EFRI recommends, prioritizes, and funds interdisciplinary project 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 prosperity even as global competition has grown. To help ensure the Nation's continued success and competitiveness in research and innovation, 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 is intended to 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 submit 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; highly secure communication using advanced quantum technologies; advances in soft robotics; flexible technologies and regenerative engineering for healthcare; and biomolecular engineering technologies that will lead to transformative strategies for the screening and treatment of pre-cancers, to solve persistent environmental problems, and uncover new plant traits for agriculture.

In general, about 63 percent of the EFMA portfolio is comprised of new research grants, and about 37 percent supports continuing increments for grants made in previous years.

DIRECTORATE FOR GEOSCIENCES (GEO) **$852,980,000**
+$27,360,000 / 3.3%

GEO Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Atmospheric & Geospace Sciences (AGS)	$253.37	-	$239.30	-$14.07	-5.6%
Earth Sciences (EAR)	179.13	-	169.23	-9.90	-5.5%
Integrative & Collaborative Education and Research (ICER)	76.38	-	104.95	28.57	37.4%
Ocean Sciences (OCE)	316.74	-	339.50	22.76	7.2%
Total	**$825.62**	**-**	**$852.98**	**$27.36**	**3.3%**

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 create and sustain vital natural resources on which society depends. Our mineral, energy, and water resources result from diverse Earth processes including the planet's water cycle, interactions across the land-ocean interface, the behavior of ice sheets, and geologic processes responsible for hydrocarbon energy sources and strategic minerals. Basic research supported by GEO contributes to the understanding of these processes and the resources that result from them. In addition, lives are saved and property is preserved by better forecasting and understanding of natural environmental hazards such as earthquakes, tornadoes, tsunamis, drought, and solar storms. GEO-supported research improves society's preparation for the effects of these and other disruptive natural events, and GEO prioritizes support for interdisciplinary studies that contribute directly to national research priorities such as mitigating the impacts of hazardous events, and understanding future availability and distribution of fresh water.

GEO activities support and promote many of NSF's Big Ideas. In particular, a number of GEO programs contribute directly to NSF's overarching theme of Navigating the New Arctic (NNA). GEO programs also contribute to Harnessing the Data Revolution for 21st-Century Science and Engineering, Understanding the Rules of Life, and NSF INCLUDES. Leveraging the knowledge and techniques of many other disciplines, GEO strongly promotes the growth of Convergence Research across all fields of science. As part of NNA, and in partnership with the other research directorates and offices, GEO will invest funds in its ICER division to support convergent activities that transcend the traditional disciplinary boundaries of individual NSF directorates and offices. These activities will enable pursuit of fundamental research in Arctic regions. While budget management and reporting for this investment will be the responsibility of GEO, the convergent activities will be overseen and managed collaboratively by the multi-directorate/office NNA leadership team.

In addition, the Office of Polar Programs (OPP) operates as part of the Directorate for Geosciences; more information on OPP can be found in the Office of Polar Programs narrative.

GEO provides about 59 percent of the federal funding for basic research at academic institutions in the atmospheric, earth, and ocean sciences.

Major Investments

GEO Major Investments
(Dollars in Millions)

Area of Investment	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
CAREER	$16.47	-	$14.02	-$2.45	-14.9%
INFEWS	7.70	-	8.00	0.30	3.9%
IUSE	5.82	-	6.00	0.18	3.1%
NSF I-Corps™	0.60	-	0.60	-	-
NSF Research Traineeship[1]	2.77	-	-	-2.77	-100.0%
PREEVENTS	17.25	-	17.25	-	-
NSF's Big Ideas					
Navigating the New Arctic		*-*	*30.00*	*30.00*	*N/A*
NSF INCLUDES[2]	*2.08*	*-*	*-*	*-2.08*	*-100.0%*

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

[1] In FY 2019, NRT funding is provided through CISE and EHR.

[2] In FY 2019, NSF INCLUDES funding is provided through the EHR account.

GEO Funding for Centers Programs and Facilities

GEO Funding for Centers Programs
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Total	**$5.00**	**-**	**$3.70**	**-$1.30**	**-26.0%**
STC: Center for Dark Energy Biosphere Investigations (OCE)	5.00	-	3.70	-1.30	-26.0%

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

GEO Funding for Facilities
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Total	**$272.51**	**-**	**$297.33**	**$24.82**	**9.1%**
Academic Research Fleet (ARF)	84.14	-	77.80	-6.34	-7.5%
Arecibo Observatory	4.10	-	3.03	-1.07	-26.1%
Geodesy Advancing Geosciences and EarthScope (GAGE)	11.58	-	10.90	-0.68	-5.9%
International Ocean Discovery Program (IODP)	48.00	-	48.00	0.00	-
National Center for Atmospheric Research (NCAR)	99.70	-	94.70	-5.00	-5.1%
National Nanotechnology Coordinated Infrastructure (NNCI)	0.30	-	-	-0.30	-100.0%
Ocean Observatories Initiative (OOI)[1]	0.34	-	40.00	39.66	11638.8%
Seismological Facilities for Advancement of Geoscience & EarthScope (SAGE)	24.35	-	22.90	-1.45	-6.0%

[1]The FY 2017 budget of $340,000 reflects only the incremental support necessary to enable the potential transition of managing institutions associated with the competition for a new operation and management award of the OOI. FY 2017 operations and maintenance were funded in a prior year.

For detailed information on individual facilities, please see the Facilities and the Major Research Equipment and Facilities Construction chapters.

Funding Profile

GEO Funding Profile

	FY 2017 Actual Estimate	FY 2018 (TBD)	FY 2019 Estimate
Statistics for Competitive Awards:			
Number of Proposals	4,088	-	4,100
Number of New Awards	1,296	-	1,300
Funding Rate	32%	-	32%
Statistics for Research Grants:			
Number of Research Grant Proposals	3,762	-	3,800
Number of Research Grants	1,130	-	1,200
Funding Rate	30%	-	32%
Median Annualized Award Size	$149,623	-	$150,000
Average Annualized Award Size	$189,006	-	$190,000
Average Award Duration, in years	2.8	-	2.8

People Involved in GEO Activities

Number of People Involved in GEO Activities

	FY 2017 Actual Estimate	FY 2018 (TBD)	FY 2019 Estimate
Senior Researchers	4,414	-	4,400
Other Professionals	2,602	-	2,600
Postdoctoral Associates	490	-	500
Graduate Students	2,318	-	2,300
Undergraduate Students	2,145	-	2,200
K-12 Teachers	-	-	-
K-12 Students	-	-	-
Total Number of People	**11,969**	**-**	**12,000**

Program Monitoring and Evaluation

External Program Evaluations and Studies:

- In FY 2017, GEO initiated an evaluation of its Education and Diversity program. Results are expected in late FY 2018 and will be used to inform internal strategic planning activities.
- The Science, Engineering, and Education for Sustainability (SEES) program, which ended in FY 2017, is currently being assessed. The evaluation is being conducted by Manhattan Strategy Group and will (1) examine the effectiveness of SEES, (2) complete a historical review of NSF's sustainability efforts in the past 15 years, and (3) review the SEES portfolio solicitations from 2010 to 2014. Final results from this study are expected in FY 2019.

Workshops and Reports:

In 2015, the National Research Council's Ocean Studies board released *Sea Change: 2015-2025 Decadal Survey of Ocean Sciences*[1]. This report greatly influenced NSF's Division of Ocean Sciences by addressing the strategic investments necessary to ensure a robust ocean science enterprise and providing guidance on research and infrastructure priorities.

In 2017, the National Academies of Sciences, Engineering, and Medicine's Space Studies Board released an *Assessment of the National Science Foundation's 2015 Geospace Portfolio Review*[2]. This study made recommendations for NSF's implementation of prior recommendations of a portfolio review.

Committees of Visitors (COV):

- In 2017, COVs reviewed Education and Diversity programs across GEO and OPP, and all programs in EAR.
- In 2018, COVs will review selected programs in two divisions; AGS and OCE.
- In 2019, a COV will review the AGS Atmosphere Section.

See Performance chapter for additional information regarding the periodic reviews of programs and portfolios of programs by external Committees of Visitors and directorate Advisory Committees not mentioned here.

[1]www.nap.edu/catalog/21655/sea-change-2015-2025-decadal-survey-of-ocean-sciences
[2]www.nap.edu/catalog/24666/assessment-of-the-national-science-foundations-2015-geospace-portfolio-review

DIVISION OF ATMOSPHERIC AND GEOSPACE SCIENCES (AGS) **$239,300,000**
-$14,070,000 / -5.6%

AGS Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Total	**$253.37**	**-**	**$239.30**	**-$14.07**	**-5.6%**
Research	**122.71**	**-**	**115.47**	**-7.24**	**-5.9%**
CAREER	4.46	-	4.00	-0.46	-10.4%
Education	**3.33**	**-**	**4.10**	**0.77**	**22.9%**
Infrastructure	**127.32**	**-**	**119.73**	**-7.59**	**-6.0%**
Arecibo Observatory	4.10	-	3.03	-1.07	-26.1%
National Center for Atmospheric Research	99.70	-	94.70	-5.00	-5.0%
Research Resources	23.52	-	22.00	-1.52	-6.5%

AGS Summary

AGS supports fundamental research activities to enable improved understanding of the dynamics of the sun, the physics, chemistry, and dynamics of the Earth's atmosphere and near-space environment, and how the sun interacts with the Earth's atmosphere. Improved understanding supports state-of-the science model development and improved predictability of weather, climate and space weather events. 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. AGS support occurs via the traditional individual investigator merit-reviewed multi-year grants, limited duration exploratory research projects, collaborative and multi-investigator group projects, and the research conducted with leadership-class facilities provided by the National Center for Atmospheric Research (NCAR). Through improvements to our understanding of severe weather events, and the development of sophisticated computer models that simulate and forecast such events and their impacts, AGS helps protect life, property, and natural resources, and contributes to the establishment of a weather-ready and space weather-ready nation. AGS-supported scientists lead innovations ranging from the miniaturization of sensors that fly on cubesats, to the creation of high-resolution models that enable prediction of a variety of severe weather hazards. AGS also funds STEM education, fosters the success of early career scientists, and supports the continuing development of a world-class scientific and technical workforce that contributes significantly to the nation's economic vitality.

About 28 percent of the AGS portfolio is available for new research grants. The remainder supports research grants made in prior years and the research infrastructure that supports the capabilities, creativity, and innovation of the atmospheric and geospace science community.

DIVISION OF EARTH SCIENCES (EAR) **$169,230,000**
-$9,900,000 / -5.5%

EAR Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Total	**$179.13**	**-**	**$169.23**	**-$9.90**	**-5.5%**
Research	**116.68**	**-**	**110.45**	**-6.23**	**-5.3%**
CAREER	8.48	-	8.02	-0.46	-5.5%
Education	**4.43**	**-**	**4.19**	**-0.24**	**-5.5%**
Infrastructure	**58.02**	**-**	**54.59**	**-3.43**	**-5.9%**
Geodetic Facilities for the Advancement of Geoscience and EarthScope (GAGE)	11.58	-	10.90	-0.68	-5.9%
Seismological Facilities for the Advancement of Geoscience and EarthScope (SAGE)	24.35	-	22.90	-1.45	-6.0%
Research Resources	22.09	-	20.79	-1.30	-5.9%

EAR Summary

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 mineral, water, biota, and energy resources, and provide methods for predicting and mitigating the effects of geologic hazards such as earthquakes, volcanic eruptions, floods, and landslides.

EAR supports research in geomorphology and land use, hydrologic science, geobiology and low temperature geochemistry, sedimentary geology and paleobiology, 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; and an education program that funds a number of activities to attract and support students and young investigators to the field of Earth science.

In general, about 38 percent of the EAR portfolio is available for new research grants and 62 percent is available for continuing grants and the research infrastructure needed by this community.

DIVISION OF INTEGRATIVE AND COLLABORATIVE EDUCATION AND RESEARCH (ICER) **$104,950,000**
+$28,570,000 / 37.4%

ICER Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Total	**$76.38**	**-**	**$104.95**	**$28.57**	**37.4%**
Research	**61.55**	**-**	**98.95**	**37.40**	**60.8%**
Big Idea: Navigating the New Arctic	-	-	30.00	30.00	N/A
Education	**14.54**	**-**	**6.00**	**-8.54**	**-58.7%**
Infrastructure	**0.30**	**-**	**-**	**-0.30**	**-100.0%**
National Nanotechnology Coordinated Infrastructure (NNCI)	0.30	-	-	-0.30	-100.0%

ICER Summary

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 2019, the division will make strategic investments in multidisciplinary research areas, international activities, education, diversity, and human resource development. The results of these investments will assist in ensuring that the U.S. has a well-educated and diverse workforce in the geosciences and in related technical fields such as resource exploration. Research at the Food-Energy-Water nexus will result in understanding interactions across the FEW nexus, how it is likely to affect our world, and how we can proactively plan for its consequences.

In FY 2019, GEO, in partnership with all of the NSF research directorates and offices, will advance the NNA Big Idea by investing ICER funds to support convergent activities that transcend the traditional disciplinary boundaries of individual NSF directorates and offices. These activities will enable pursuit of fundamental research in the Arctic. While budget management and reporting for this investment will be the responsibility of GEO, the convergent activities will be overseen and managed collaboratively by the multi-directorate/office NNA leadership team.

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

DIVISION OF OCEAN SCIENCES (OCE) **$339,500,000**
+$22,760,000 / 7.2%

OCE Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Total	**$316.74**	**-**	**$339.50**	**$22.76**	**7.2%**
Research	**167.44**	**-**	**159.86**	**-7.58**	**-4.5%**
CAREER	3.52	-	2.00	-1.52	-43.2%
Centers Funding (total)	5.00	-	3.70	-1.30	-26.0%
STC: Center for Dark Energy Biosphere Investigations	5.00	-	3.70	-1.30	-26.0%
Education	**4.84**	**-**	**4.84**	-	**-**
Infrastructure	**144.46**	**-**	**174.80**	**30.34**	**21.0%**
Academic Research Fleet (ARF)	82.03	-	77.80	-4.23	-5.2%
International Ocean Discovery Program (IODP)	48.00	-	48.00	-	-
Ocean Observatories Initiative (OOI)	0.34	-	40.00	39.66	11638.8%
Polar Logistics	0.09	-	-	-0.09	-100.0%
Research Resources	11.89	-	9.00	-2.89	-24.3%
Facilities Development and Design (total)	2.11	-	-	-2.11	-100.0%
Regional Class Research Vessels (RCRV)	2.11	-	-	-2.11	-100.0%

OCE Summary

OCE supports interdisciplinary research, education, and cutting-edge infrastructure that advances our scientific knowledge of the oceans to support the U.S. economy over the long term, provides vital information regarding national security matters such as sea level rise and harmful algal blooms, and advances U.S. leadership in ocean science and technological innovation. OCE provides support of basic scientific research and technology 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 the occurrence of methane hydrates, natural hazards associated with earthquakes, tsunamis, and volcanic eruptions, microbial life deep below the seafloor, and other fundamental ocean processes. Ocean education emphasizes the interdisciplinary nature of ocean sciences, and commonly leverages research facilities and infrastructure via telepresence to far and distant seas. 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. Broadly speaking, research, education, and infrastructure funded by OCE addresses the central role of the oceans in a changing Earth and as a national strategic resource, as recognized by numerous reviews by external bodies (e.g., National Academy of Sciences Decadal Survey *Sea Change, 2015-2025*).

In general, 39 percent of the OCE portfolio is available for new research grants, with the rest supporting grants made in prior years and the research infrastructure needed by this community.

DIRECTORATE FOR MATHEMATICAL AND PHYSICAL SCIENCES (MPS) **$1,345,320,000**
-$17,110,000 / -1.3%

MPS Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Percent
Astronomical Sciences (AST)	$252.05	-	$230.69	-$21.36	-8.5%
Chemistry (CHE)	246.24	-	230.58	-15.66	-6.4%
Materials Research (DMR)	314.31	-	295.05	-19.26	-6.1%
Mathematical Sciences (DMS)	233.54	-	218.82	-14.72	-6.3%
Physics (PHY)	281.43	-	266.73	-14.70	-5.2%
Office of Multidisciplinary Activities (OMA)	34.86	-	103.45	68.59	196.8%
Total	**$1,362.43**	**-**	**$1,345.32**	**-$17.11**	**-1.3%**

About MPS

MPS serves the Nation by supporting fundamental discoveries at the forefront of science. These discoveries form a tapestry of knowledge and innovation that transforms the future. Research in the disciplines supported by MPS has led to advances that are used for a wide variety of applications; examples include laser technology, navigation using the Global Positioning System, materials fundamental to integrated circuits, and algorithms used for advanced cybersecurity. The FY 2019 Budget Request for MPS supports a collection of vigorous disciplinary and multidisciplinary research programs that foster discovery and cultivate the technical workforce. Awards funded by MPS provide the foundations of basic research in astronomical sciences, chemistry, materials research, mathematical sciences, and physics that explore the frontiers of science.

The programs in MPS span the range from individual investigator awards to large, multi-user facilities. The science spans an enormous range as well: from the smallest objects and shortest times ever studied to distances and times that are the size and age of the universe. Individual investigators and small teams receive most awards, but centers, institutes, and multi-user facilities are all integral to MPS-funded research. MPS continues to participate in NSF-wide investments and multi-directorate activities, particularly ones that connect to the fundamental research at the heart of its mission. These multi-directorate activities include growing MPS foundational research for several of the Big Ideas that are discussed elsewhere in this document.

Programs in the MPS divisions respond to special intellectual opportunities and reflect careful choices to provide the greatest return on the research investment. Identifying these opportunities involves the community, through the MPS Advisory Committee and through groups chartered to identify prospects, for revolutionary science in particular areas. Input from the National Academies of Sciences, Engineering, and Medicine (the National Academies) is critical for prioritization; two recent examples are New Worlds, New Horizons: A Midterm Assessment (delivered in August 2016) and Frontiers of Materials Research: A Decadal Survey (scheduled for completion in FY 2018).

Facilities that enable unique science that would be impossible without the special resources of a shared, multi-user environment are integral to our mission. 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 isotopes. Stewardship of the MPS facilities portfolio and the balance among the different awards programs are critical issues that also engender extensive community

consultation. MPS continues assessing the future of different facilities and fostering collaborations for those facilities.

In partnership with other research directorates and offices, MPS will participate in building the foundation for the Big Ideas described previously. In particular, FY 2019 investments will advance the work of several of the Research Big Ideas, including Windows on the Universe: The Era of Multi-Messenger Astrophysics (WoU); The Quantum Leap: Leading the Next Quantum Revolution (QL); Harnessing the Data Revolution for 21st-Century Science and Engineering (HDR); Understanding the Rules of Life: Predicting Phenotype (URoL); and The Future of Work at the Human-Technology Frontier (FW-HTF).

In FY 2019, MPS will invest OMA funds to advance QL and WoU Big Ideas. These convergent activities will enable pursuit of fundamental research in quantum enabled sciences and technologies and multi-messenger astrophysics. By exploiting quantum phenomena such as superposition, entanglement, and squeezing, the QL activities will develop the foundations for and enable quantum computing, quantum sensors, quantum communications, quantum simulators, and other inherently quantum technologies, enhancing the social sciences and informing discussions on the social impacts of quantum innovation. The WoU activities will bring together fundamental research in electromagnetic waves, high-energy particles and gravitational waves; advance the study of the universe; and grow the Nation's multi-messenger astrophysics, engineering and data science workforce. While budget management and reporting for these investments will be the responsibility of MPS, the convergent activities will be overseen and managed collaboratively by the multi-directorate/office QL and WoU leadership teams.

MPS provides about 49 percent of the federal funding for basic research at academic institutions in the mathematical and physical sciences.

Major Investments

MPS Major Investments
(Dollars in Millions)

Area of Investment	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
CAREER	$90.32	-	$70.94	-$19.38	-21.5%
INFEWS[1]	8.78	-	-	-8.78	-100.0%
NSF I-Corps™	1.69	-	1.70	0.01	0.6%
NSF Research Traineeship[2]	4.54	-	-	-4.54	-100.0%
SaTC	1.03	-	1.00	-0.03	-2.9%
UtB	25.46	-	13.30	-12.16	-47.8%
BRAIN Initiative	*25.46*	-	*13.30*	*-12.16*	*-47.8%*
NSF's Big Ideas					
NSF INCLUDES[3]	*2.22*	-	-	*-2.22*	*-100.0%*
Quantum Leap	-	-	*30.00*	*30.00*	*N/A*
Windows on the Universe	-	-	*30.00*	*30.00*	*N/A*

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

[1]In FY 2019, INFEWS funding declined due to other priorities.

[2]In FY 2019, NRT funding is provided through CISE and EHR.

[3]In FY 2019, NSF INCLUDES funding is provided through the EHR account.

MPS Funding for Centers Programs and Facilities

MPS Funding for Centers Programs
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Total	**$97.50**	**-**	**$91.00**	**-$6.50**	**-6.7%**
Centers for Analysis & Synthesis (DMS)	0.20	-	-	-0.20	-100.0%
Centers for Chemical Innovation (CHE)	20.87	-	20.00	-0.87	-4.2%
Materials Research Science & Engineering Centers (DMR)[1]	62.13	-	56.00	-6.13	-9.9%
Nanoscale Science & Engineering Centers (CHE, DMR)	0.50	-	-	-0.50	-100.0%
STC: Center for Integrated Quantum Materials (DMR)	4.20	-	5.00	0.80	19.0%
STC: STC for Real-Time Functional Imaging (DMR)	5.00	-	5.00	-	-
STC: Center for Bright Beams (PHY)	4.60	-	5.00	0.40	8.7%

[1]Includes forward funding of $6.13 million in FY 2017.

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

MPS Funding for Facilities
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Total	**$289.17**	**-**	**$298.37**	**$9.20**	**3.2%**
Arecibo Observatory	3.90	-	3.05	-0.85	-21.8%
Atacama Large Millimeter Array (ALMA)	44.98	-	40.28	-4.70	-10.4%
Cornell High Energy Synchrotron (CHESS)[1]	16.20	-	10.00	-6.20	-38.3%
Daniel K. Inouye Solar Telescope (DKIST)[2]	13.50	-	18.50	5.00	37.0%
Gemini Observatory	24.24	-	21.66	-2.58	-10.6%
IceCube Neutrino Observatory (IceCube)	3.50	-	3.50	-	-
Large Hadron Collider (LHC)[3]	16.00	-	16.00	-	-
Large Synoptic Survey Telescope (LSST)	-	-	0.50	0.50	N/A
Laser Interferometer Gravitational Wave Observatory (LIGO)[4]	41.93	-	45.00	3.07	7.3%
National High-Magnetic Field Laboratory (NHMFL)[5]	23.15	-	35.76	12.61	54.5%
National Nanotechnology Coordinated Infrastructure (NNCI)	2.88	-	2.50	-0.38	-13.2%
National Optical Astronomy Observatories (NOAO)	22.99	-	20.13	-2.86	-12.4%
National Radio Astronomy Observatories (NRAO)	31.67	-	38.85	7.18	22.7%
National Solar Observatory (NSO)[6]	6.00	-	4.00	-2.00	-33.3%
National Superconducting Cyclotron Laboratory (NSCL)	24.00	-	24.00	-	-
Other MPS Facilities:	14.23	-	14.64	0.41	2.9%
Center for High Resolution Neutron Scattering (CHRNS)	2.78	-	2.79	0.01	0.4%
Other Astronomical Facilities (LBO, GBO)	11.45	-	11.85	0.40	3.5%

[1]Includes forward funding of $8.20 million in FY 2017.

[2]Includes $2.0 million per year for cultural mitigation activities as required by the compliance process.

[3]Excludes $5.71 million in FY 2017 and $6.30 million in FY 2019 for High-Lumosity LHC Upgrade planning.

[4]Includes one-time supplemental funding of $2.50 million in FY 2017 for a critical vacuum repair.

[5]CHE and DMR forward funded NHMFL by $1.92 million and $10.73 million respectively in FY 2016. This reduced the FY 2017 total needed by $12.65 million.

[6]Excludes $11.50 million in FY 2017 and $16.50 million in FY 2019 for operations and maintenance support for the DKIST construction project. This funding is included in the DKIST total presented above.

For detailed information on individual facilities, please see the Facilities and the Major Research Equipment and Facilities Construction chapters.

Funding Profile

MPS Funding Profile

	FY 2017 Actual Estimate	FY 2018 (TBD)	FY 2019 Estimate
Statistics for Competitive Awards:			
Number of Proposals	8,849	-	9,000
Number of New Awards	2,335	-	2,300
Funding Rate	26%	-	26%
Statistics for Research Grants:			
Number of Research Grant Proposals	7,754	-	8,000
Number of Research Grants	1,853	-	1,800
Funding Rate	24%	-	23%
Median Annualized Award Size	$120,000	-	$120,000
Average Annualized Award Size	$139,127	-	$140,000
Average Award Duration, in years	3.2	-	3.2

People Involved in MPS Activities

Number of People Involved in MPS Activities

	FY 2017 Actual Estimate	FY 2018 (TBD)	FY 2019 Estimate
Senior Researchers	8,102	-	7,900
Other Professionals	3,271	-	3,100
Postdoctoral Associates	2,059	-	2,000
Graduate Students	8,828	-	8,600
Undergraduate Students	6,121	-	5,900
K-12 Teachers	-	-	-
K-12 Students	-	-	-
Total Number of People	**28,381**	**-**	**27,500**

Program Monitoring and Evaluation

External Program Evaluations and Studies:

- The Astronomy and Astrophysics Advisory Committee (AAAC) completed its report[1] on interagency activities by NSF, the Department of Energy (DOE), and the National Aeronautics and Space Administration (NASA) in March 2017. Findings and recommendations of this annual report help guide AST decision making and prioritization until superseded by a subsequent report. The AAAC held three meetings in early FY 2018 that will lead up to their next annual report, expected in March.
- AST, together with the NASA Astrophysics Division and the High Energy Physics Branch of the DOE Office of Science, commissioned a study (*Review of Progress Toward the Decadal Survey Vision in New Worlds, New Horizons in Astronomy and Astrophysics*) of the mid-term status of agency responses to the 2010 decadal survey in astronomy and astrophysics, through the NRC Space Studies Board. The resulting NRC mid-term review committee report was published in August 2016.[2] Findings and recommendations of this "mid-decadal" report will guide AST decision making and prioritization until

[1]www.nsf.gov/mps/ast/aaac.jsp
[2]http://sites.nationalacademies.org/SSB/CurrentProjects/SSB_161177

superseded by the next "decadal" report, expected in the early part of the 2020s.

- Pursuant to the National Environmental Policy Act of 1969, AST has prepared or is in the process of preparing Environmental Impact Statements (EIS) for three AST facilities: Arecibo Observatory, Sacramento Peak Observatory, and Green Bank Observatory.[3] These statements are intended to study and evaluate the potential environmental effects of proposed operational changes to these facilities due to funding constraints. Prior to finalization, the general public has several opportunities to review draft documents and provide external, independent formal input into the formulation of the final EIS. For two of these facilities, Sacramento Peak and Green Bank Observatories, the process is on-going. For Arecibo Observatory, a final EIS was published in July 2017. In November 2017, NSF signed a Record of Decision for Arecibo Observatory, which concluded the agency's decision-making process with respect to the general path forward for Arecibo Observatory.[4]
- The CCI program is being assessed through an evaluation. Final results are expected in FY 2019.
- DMR co-sponsored with the DOE Office of Basic Energy Sciences (BES) a National Academies Decadal Survey entitled *Frontiers of Materials Research*. This important study will identify future needs and important emerging research areas of materials research in the context of U.S. and international efforts.[5] A report, anticipated in June 2018, will inform DMR of future directions.
- In FY 2019, PHY plans to charge the National Academies with a Decadal Survey of Atomic, Molecular, and Optical Physics, together with DOE BES.
- In FY 2019, PHY plans to charge the MPS Advisory Committee to study the implementation of its Physics Frontiers Centers Program.

Workshops and Reports:

- In October 2016, a CHE-sponsored workshop titled *Measuring the Brain: From the Synapse to Thought* brought together the chemical and neuroscience communities to identify challenges in brain research and how chemical probes, sensors, and instrumentation could address challenges in understanding brain functioning. The report is now available.[6]
- CHE sponsored two 2016 workshops on midscale investment opportunities. The first resulted in *Mid-Scale Instrumentation: Regional Facilities to Address Grand Challenges in Chemistry.*[7] This report focuses on six "grand challenges" for regional facilities in the chemical community (e.g., structure and dynamics at interfaces, highly parallel chemical synthesis and characterization, structure-function relationships in disordered and/or heterogeneous systems, etc.). The second 2017 report, *Workshop on Midscale Instrumentation Development for the Chemical Sciences*,[8] focuses on instrument development that could impact the chemical community and closely associated industries in the U.S. and globally (e.g., fuels, energy, commodity chemicals and materials, and medicine).
- The CHE workshop *Quantum Information and Computation for Chemistry* was held in November 2016, with representatives attending from the chemical community, the National Academies, multiple federal agencies, and industries involved in quantum sciences. The workshop explored the boundaries between classical and quantum computation, quantum machine learning, quantum optical tools for chemistry, and sensing and communication applications. A report is available.[9]
- The CHE workshop *Framing the Role of Big Data and Modern Data Science in Chemistry* was held in April 2017 and focused on big data research and the use of modern data science in chemistry. The workshop addressed the needs of the chemical research and data science communities to fully develop

[3]www.nsf.gov/news/news_summ.jsp?cntn_id=139158&org=AST
[4]www.nsf.gov/mps/ast/env_impact_reviews/arecibo/arecibo_rod.jsp
[5]http://sites.nationalacademies.org/DEPS/materials-decadal/index.htm
[6]www.nsf.gov/mps/che/measuring_the_brain_from_synapse_to_thought_10_2016.pdf
[7]www.nsf.gov/mps/che/workshops/msiegionalcenters_workshopreport_5_1_17.pdf
[8]www.nsf.gov/mps/che/workshops/mid-scale_instrument_development_for_the_chemical_sciences_workshop_september_2016.pdf
[9]www.nsf.gov/mps/che/workshops/che_qis_workshop_november_2016.pdf

sharing, searching, and repurposing for data mining, machine learning, and data analytics. The report will be available in FY 2018.

- DMR sponsored several workshops in FY 2017 and FY 2018 aimed at building the materials research community,[10,11] preparing the community to better respond to the NSF QL Big Idea,[12,13,14] and developing critical skills in the use of data-driven research.[15,16] In addition, DMR sponsored a study from The Minerals, Metals & Materials Society (TMS) titled *Building a Materials Data Infrastructure: Opening New Pathways to Discovery and Innovation in Science and Engineering* which recommends potential methods of effectively storing and maintaining data, the value of data by enabling its reuse, and creating incentives that encourage data sharing.[17]
- DMR will sponsor several workshops throughout FY 2018 and FY 2019 that will focus on condensed matter science, quantum materials,[18] solid state materials chemistry, metals, and the application of data-driven science and machine learning to accelerated materials discovery,[19] and best practices in managing shared research instrumentation Facilities.
- In October 2017, DMS and the CISE Division of Computing and Communication Foundations sponsored a Kickoff Principle Investigator (PI) meeting for the joint Transdisciplinary Research in Principles of Data Science (TRIPODS) program that supported the development of small collaborative institutes bringing together mathematicians, statisticians, and theoretical computer scientists. All 12 TRIPODS groups that received awards in the summer of 2017 participated, presented their planned activities, and discussed opportunities for future collaborations with domain sciences and industry.
- In September 2017, DMS and the National Geospatial Intelligence Agency sponsored a PI meeting for the joint program on Algorithms for Threat Detection. The program focuses on research to develop the next generation of mathematical and statistical algorithms for analysis of large spatiotemporal datasets with application to quantitative models of human dynamics.[20]
- In collaboration with the National Institutes of Health (NIH), DMS supported a Data Science Innovation Lab workshop in June 2017. The goal of the workshop was to foster new interdisciplinary collaborations to support the development of innovative approaches for visualization, modeling, and analysis of microbiome big data. The activity brought together researchers in quantitative and biomedical sciences with a goal of developing new research teams to address data science challenges in furthering our understanding of the microbiome. Prior Innovation Labs have focused on Precision Medicine (2015) and Mobile Health (2016).
- DMS co-sponsored (with CISE, EHR, SBE) a National Academies study "Envisioning the Data Science Discipline: The Undergraduate Perspective" with the goal of understanding the "core underlying principles, intellectual content, and pedagogical issues specific to data science, including core concepts that distinguish it from neighboring disciplines." A workshop in May 2017 brought together stakeholders from different disciplines and types of institutions. Following the workshop, the committee issued an interim report[21] and organized webinars to obtain feedback from the community. A follow-up workshop was held in December 2017; the final report is expected in 2018.

[10]http://reg.conferences.dce.ufl.edu/Physics/1202
[11]https://sites.cns.utexas.edu/epm_nsf_workshop
[12]https://scholar.princeton.edu/nsfcmp/home
[13]http://qs3.mit.edu/images/pdf/2017-QS3-Detailed-Schedule.pdf
[14]https://nsfhighfield.princeton.edu/
[15]https://mrsec.uchicago.edu/mat_summit
[16]www.mri.psu.edu/2d-crystal-consortium/nsf-efri-2daredmref-2dmip-grantees-meeting
[17]www.tms.org/mdistudy
[18]http://qs3.mit.edu/index.php/summer-school-program
[19]https://matdat18.wordpress.ncsu.edu/
[20]https://atd2017.soe.ucsc.edu/home
[21]www.nap.edu/catalog/24886/envisioning-the-data-science-discipline-the-undergraduate-perspective-interim-report

Committees of Visitors (COV):

- In FY 2019, COVs will review AST, DMR, and PHY.
- In FY 2020, COVs will review CHE and 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.

DIVISION OF ASTRONOMICAL SCIENCES (AST) **$230,690,000**
-$21,360,000 / -8.5%

AST Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Total	**$252.05**	**-**	**$230.69**	**-$21.36**	**-8.5%**
Research	**60.43**	**-**	**55.17**	**-5.26**	**-8.7%**
CAREER	4.83	-	4.90	0.07	1.4%
Education	**4.24**	**-**	**5.70**	**1.46**	**34.4%**
Infrastructure	**187.38**	**-**	**169.82**	**-17.56**	**-9.4%**
Arecibo Observatory	3.90	-	3.05	-0.85	-21.8%
Atacama Large Mm/SubMm Array (ALMA)	44.98	-	40.28	-4.70	-10.4%
Daniel K. Inouye Solar Telescope (DKIST)[1]	13.50	-	18.50	5.00	37.0%
Gemini Obervatory[2]	24.24	-	21.66	-2.58	-10.6%
Large Synoptic Survey Telescope (LSST)	-	-	0.50	0.50	N/A
National Optical Astronomy Obervatory (NOAO)	22.99	-	20.13	-2.86	-12.4%
National Radio Astronomy Obervatory (NRAO)	31.67	-	38.85	7.18	22.7%
National Solar Observatory (NSO)[3]	6.00	-	4.00	-2.00	-33.3%
Other Astronomical Obervatories (LBO, GBO)	11.45	-	11.85	0.40	3.5%
Mid-Scale Innovations Program (MSIP)	20.67	-	1.00	-19.67	-95.2%
Research Resources	7.98	-	10.00	2.02	25.3%

[1]Includes $2.0 million per year for cultural mitigation activities as required by the compliance process.

[2]Includes a technical reobligation of $3.74 million in FY 2017 at the end of an expiring coop. support

[3]Excludes $11.50 million in FY 2017 and $16.50 million in FY 2019 for operations and maintenance support for the DKIST construction project. This funding is included within the DKIST line above.

AST Summary

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

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, 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.

AST contributes to WoU with investments in facilities that support ground-based electromagnetic follow-up as well as projects that employ pulsars as an alternative gravitational wave detection method.

In general, about 19 percent of the AST portfolio is available for new research grants. About 72 percent of AST's budget supports the forefront instrumentation and facilities needed for progress at the frontiers of observational astronomy, while almost 24 percent supports the research of individual investigators. Through the MREFC Account, AST also oversees the construction of LSST and DKIST.

DIVISION OF CHEMISTRY (CHE) **$230,580,000**
-$15,660,000 /-6.4%

CHE Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Total	**$246.24**	**-**	**$230.58**	**-$15.66**	**-6.4%**
Research	**232.61**	**-**	**216.75**	**-15.86**	**-6.8%**
CAREER	35.19	-	22.71	-12.48	-35.5%
Centers Funding (total)	21.12	-	20.00	-1.12	-5.3%
Centers for Chemical Innovation	20.87	-	20.00	-0.87	-4.2%
Nanoscale Science & Engineering Centers	0.25	-	-	-0.25	-100.0%
Education	**6.06**	**-**	**5.10**	**-0.96**	**-15.8%**
Infrastructure	**7.57**	**-**	**8.73**	**1.16**	**15.3%**
National Nanotechnology Coordinated Infrastructure (NNCI)	0.30	-	-	-0.30	-100.0%
National High Magnetic Field Laboratory (NHMFL)[1]	-	-	1.73	1.73	N/A
Research Resources	7.27	-	7.00	-0.27	-3.7%

[1]Forward funding of $1.92 million in FY 2016 reduced the planned FY 2017 increment to zero. Without this action, the change from FY 2017 Actual would be -$190,000, or -9.9 percent.

CHE Summary

The chemical industry is one of the largest and most important industries worldwide both in terms of impact on the economy and employment. It includes sectors in energy, pharmaceuticals and medical applications, electronics, agriculture, textiles, building products, and numerous other commercial and consumer products. CHE leads the discovery, invention, innovation, and development of a skilled workforce capable of fundamental and foundational research that ultimately supports commercial manufacturing in the chemical industries. Specifically, CHE enables research on the synthesis and characterization of new molecules, surfaces, and nanostructures (by both theoretical and experimental methods) that lead to usable products beneficial to society.

CHE contributes to building the foundation for several of NSF's Big Ideas including: HDR by promoting data discovery sciences to effectively and efficiently mine extensive volumes and varieties of chemical data in order to advance discovery and innovation; QL by contributing to the production of next generation technologies at the quantum level by observing, manipulating, and controlling the behavior of matter and energy in nanometer dimensions; and URoL by increasing knowledge of the structure-function relationships in biological systems leading to important advances in understanding the human body and improving health.

CHE is also involved in the development of new mid-scale instrumentation to examine and solve complex chemical problems including the synergistic combinations of multiple types of measurement (including remote access and cyber-enabled tools) and the development of novel, new instruments. Such tool development is essential for continuing progress in fields as diverse as understanding the brain, sensing for agriculture and forensics applications, and improving the sustainable and responsible advanced manufacturing of chemical feedstocks as they transition from the lab bench to commercial scales.

About 67 percent of the CHE portfolio is available to support new research grants. The remaining 33 percent supports research grants made in prior years and the research infrastructure needed by this community.

DIVISION OF MATERIALS RESEARCH (DMR) **$295,050,000**
-$19,260,000 / -6.1%

DMR Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 Request	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Total	**$314.31**	**-**	**$295.05**	**-$19.26**	**-6.1%**
Research	**248.95**	**-**	**234.84**	**-14.11**	**-5.7%**
CAREER	26.38	-	24.03	-2.35	-8.9%
Centers Funding (total)	71.58	-	66.00	-5.58	-7.8%
Materials Research Science & Engineering Centers[1]	62.13	-	56.00	-6.13	-9.9%
Nanoscale Science & Engineering Centers	0.25	-	-	-0.25	-100.0%
STC: Center for Integrated Quantum Materials	4.20	-	5.00	0.80	19.0%
STC: Science and Technology Center on Real-Time Functional Imaging	5.00	-	5.00	-	-
Education	**4.83**	**-**	**2.13**	**-2.70**	**-55.9%**
Infrastructure	**60.53**	**-**	**58.08**	**-2.45**	**-4.0%**
Cornell High Energy Synchrotron Source (CHESS)[2]	16.20	-	10.00	-6.20	-38.3%
National High Magnetic Field Laboratory (NHMFL)[3]	23.15	-	34.03	10.88	47.0%
Center for High Resolution Neutron Scattering (CHRNS)	2.79	-	2.79	-	-
National Nanotechnology Coordinated Infrastructure (NNCI)	2.58	-	2.50	-0.08	-3.1%
Mid-scale Research Infrastructure[4]	12.86	-	6.31	-6.55	-50.9%
Research Resources	2.95	-	2.45	-0.50	-16.9%

[1]Includes forward funding of $6.13 million in FY 2017. Without this action, FY 2019 would be level with FY 2017.

[2]Includes forward funding of $8.20 million for DMR's increment in FY 2017. Without this action, the change from FY 2017 Actual would be $2.0 million, or 25.0 percent.

[3]DMR forward funded its increment by $10.73 million in FY 2016, reducing the planned FY 2017 increment. Without this action, the change from FY 2017 Actual would be +$150,000 or +0.4 percent.

[4]Includes forward funding of $6.09 million in FY 2017. Without this action, the change over FY 2017 Actual would be -$460,000, or -6.8 percent.

DMR Summary

DMR invests in the discovery of new materials and the explanation of materials phenomena. Materials are ubiquitous and pervasive, serving as the critical building blocks to modern technology and innovation. DMR accomplishes this through support of basic experimental and theoretical materials research via programs focused on condensed matter physics, solid-state and materials chemistry, and the science of materials that are ceramic, metallic, polymeric, nano-structured, biological, electronic, photonic, and multifunctional. The discovery and deployment of new materials have shaped our understanding of our world and enabled significant advances in electronics, communications, transportation, and health. This enterprise is dependent on investments across scales; from single investigators to teams and centers; to singularly focused research versus that requiring interdisciplinarity; and small instruments to large facilities.

DMR contributes to building the foundations for several Big Ideas, including QL with investments in high-risk/high-impact projects in topical materials research programs, and HDR via awards that focus on using and exploiting digital data to advance materials research.

In general, within the core programs (topical materials research programs) 34 percent of the DMR portfolio is available for new research grants and 66 percent is available for continuing grants.

DIVISION OF MATHEMATICAL SCIENCES (DMS) **$218,820,000**
-$14,720,000 / -6.3%

DMS Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Total	**$233.54**	**-**	**$218.82**	**-$14.72**	**-6.3%**
Research	**220.72**	**-**	**207.20**	**-13.52**	**-6.1%**
CAREER	13.57	-	12.00	-1.57	-11.6%
Centers Funding (total)	0.20	-	-	-0.20	-100.0%
Centers for Analysis & Synthesis	0.20	-	-	-0.20	-100.0%
Education	**12.82**	**-**	**11.62**	**-1.20**	**-9.4%**

DMS Summary

DMS provides U.S. federal support of basic research at the frontiers of discovery in the mathematical sciences. 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 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 methodologies, theories, 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 programs in mathematics and statistics, DMS supports the Mathematical Sciences Research Institutes program that advances research, increases the impact of the mathematical sciences, responds to national needs, and expands the U.S. talent base engaged in mathematical and statistical research. Through partnerships with other divisions in NSF, other government agencies, and a private foundation, DMS is able to support foundational research related to several of the NSF Big Ideas, including HDR, URoL, FW-HTF, and QL. Partnerships include: joint activities in biosciences with the National Institutes of Health, a joint program with the National Geospatial Intelligence Agency to develop the next generation of mathematical and statistical algorithms for analysis of large spatiotemporal datasets, and a joint program on Algorithms for Modern Power Systems with DOE. Other examples include a joint program with CISE to support the development of small collaborative institutes called the Transdisciplinary Research in Principles of Data Science (TRIPODS) program, as well as a joint program with BIO and the Simons Foundation to support research centers on the Mathematics of Complex Biological Systems.

In general, 47 percent of the DMS portfolio is available for new research grants and 53 percent goes to continuing grants.

DIVISION OF PHYSICS (PHY) **$266,730,000**
-$14,700,000 / -5.2%

PHY Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change Over FY 2017 Actual Amount	Change Over FY 2017 Actual Percent
Total	**$281.43**	**-**	**$266.73**	**-$14.70**	**-5.2%**
Research	**178.57**	**-**	**159.01**	**-19.56**	**-11.0%**
CAREER	10.04	-	7.30	-2.74	-27.3%
Centers Funding (total)	4.60	-	5.00	0.40	8.7%
STC: Center for Bright Beams	4.60	-	5.00	0.40	8.7%
Education	**5.87**	**-**	**4.92**	**-0.95**	**-16.2%**
Infrastructure	**96.99**	**-**	**102.80**	**5.81**	**6.0%**
IceCube Neutrino Observatory (IceCube)	3.50	-	3.50	-	0.0%
Large Hadron Collider (LHC)	16.00	-	16.00	-	0.0%
Laser Interferometer Gravitational Wave Observatory (LIGO)[1]	41.93	-	45.00	3.07	7.3%
National Superconoducting Cyclotron Laboratory (NSCL)	24.00	-	24.00	-	0.0%
Midscale Research Infrastructure	5.85	-	8.00	2.15	36.8%
Pre-construction Planning:					
High-Luminosity LHC Upgrade Planning	5.71	-	6.30	0.59	10.3%

[1]FY 2017 includes one-time supplemental funding of $2.50 million for a critical vacuum repair.

PHY Summary

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 research in the U.S. in gravitational physics and the leading supporter of fundamental research in atomic, molecular, and optical physics in the United States. 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. As a result, the division contributes to building the foundation for several of NSF's Big Ideas including WoU, QL, URoL, and HDR.

Approximately 18 percent of the PHY portfolio is available for new research grants. The remaining 82 percent is used primarily to fund continuing grants made in previous years (47 percent) and to support operations and maintenance for four facilities that are a key part of the division portfolio (36 percent).

OFFICE OF MULTIDISCIPLINARY ACTIVITIES (OMA) **$103,450,000**
+$68,590,000 / 196.8%

OMA Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Total	**$34.86**	**-**	**$103.45**	**$68.59**	**196.8%**
Research	**25.55**	**-**	**96.71**	**71.16**	**278.5%**
Big Idea: Quantum Leap	-	-	30.00	30.00	N/A
Big Idea: Windows on the Universe	-	-	30.00	30.00	N/A
CAREER	0.31	-	-	-0.31	-100.0%
Education	**9.22**	**-**	**-**	**-9.22**	**-100.0%**
Infrastructure	**0.09**	**-**	**6.74**	**6.65**	**7388.9%**
Portfolio Analysis[1]	0.09	-	6.74	6.65	7388.9%

[1]FY 2017 actions were unexpectedly low due, in part, to the timing of contracts and the phases of operation of various research facilities under review.

OMA Summary

OMA co-funds research that is relevant to the broad swath of scientific disciplines represented in the five disciplinary divisions of MPS. 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 undertaken by multi-investigator, multidisciplinary teams, as well as cross-NSF and interagency activities.

In FY 2019, MPS, in partnership with NSF research directorates and offices, will invest OMA funds to advance the QL and the WoU Big Ideas. These convergent activities will enable pursuit of fundamental research in quantum enabled sciences and technologies and multi-messenger astrophysics. By exploiting quantum phenomena such as superposition, entanglement, and squeezing, the QL activities will develop the foundations for and enable quantum computing, quantum sensors, quantum communications, quantum simulators, and other inherently quantum technologies, enhancing the social sciences and informing discussions on the social impacts of quantum innovation. The Windows activities will bring together fundamental research in electromagnetic waves, high-energy particles and gravitational waves, advance the study of the universe and grow the nation's multi-messenger astrophysics, engineering and data science workforce.

While budget management and reporting for these investments will be the responsibility of MPS, the convergent activities will be overseen and managed collaboratively by the multi-directorate/office QL and WoU leadership teams. OMA will also support division investments in HDR, URoL, and FW-HTF.

OMA's practice is to commit funds using only the current fiscal year budget and to limit commitments to outyear support. For this reason, nearly 48 percent of the OMA portfolio is available to support new research grants. Approximately 39 percent of the OMA portfolio is used to support multidisciplinary research grants within MPS, with the remaining 61 percent being used to support research and education activities of interest to MPS but led by non-MPS directorates.

DIRECTORATE FOR SOCIAL, BEHAVIORAL AND ECONOMIC SCIENCES (SBE) **$246,190,000**
-$24,700,000 / -9.1%

SBE Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Percent
Social and Economic Sciences (SES)	$97.87	-	$86.68	-$11.19	-11.4%
Behavioral and Cognitive Sciences (BCS)	94.75	-	84.95	-9.80	-10.3%
National Center for Science and Engineering Statistics (NCSES)	51.19	-	51.19	-	-
SBE Office of Multidisciplinary Activities (SMA)	27.08	-	23.37	-3.71	-13.7%
Total	**$270.89**	**-**	**$246.19**	**-$24.70**	**-9.1%**

About SBE

The goals of SBE are to promote the understanding of people and their lives by supporting research that advances fundamental knowledge about human behavior and social institutions; to encourage research that addresses important societal problems and questions in the national interest; to work with other scientific disciplines to ensure that basic research and solutions to problems build upon the best disciplinary and multidisciplinary science; and to provide mission-critical statistical information about the Science and Engineering (S&E) enterprise in the United States and the world through the National Center for Science and Engineering Statistics (NCSES). SBE supports research across a diverse range of sciences that include anthropology, archaeology, economics, geography, linguistics, neuroscience, political science, psychology, sociology, and statistics. In addition, the directorate combines these disciplinary sciences in interdisciplinary activities linking them to each other and to other science and engineering fields. SBE plays a role as a major partner across the agency due to the relevance of the social, behavioral, and economic sciences in NSF priority investments.

SBE seeks to invest in the next generation of scientists who will be able to capitalize on the growing availability of massive amounts of different types of data to advance knowledge about human behavior—for example, to use and combine data from surveys, administrative records, brain imaging, and biospecimen analysis, as well as output from behavioral, environmental, and geographic sensors. As young scientists embark on their careers, they bring novel and far reaching ideas into play that can transform the future and seed the next harvest of discoveries in the social, behavioral, and economic sciences.

SBE provides approximately 68 percent of the federal funding for basic research at academic institutions in the social, behavioral, and economic sciences.

Major Investments

SBE Major Investments
(Dollars in Millions)

Area of Investment	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
CAREER	$11.70	-	$7.37	-$4.33	-37.0%
INFEWS	4.50	-	2.50	-2.00	-44.4%
NSF I-Corps™	0.49	-	0.50	0.01	2.4%
NSF Research Traineeship[1]	1.44	-	-	-1.44	-100.0%
Risk and Resilience[2]	3.19	-	-	-3.19	-100.0%
SaTC	4.30	-	4.00	-0.30	-7.0%
Understanding the Brain	27.78	-	24.00	-3.78	-13.6%
BRAIN Initiative	*7.43*	*-*	*6.17*	*-1.26*	*-17.0%*
NSF's Big Ideas					
NSF INCLUDES[3]	*0.43*	*-*	*-*	*-0.43*	*-100.0%*

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

[1] In FY 2019, NRT funding is provided through CISE and EHR.

[2] Risk and Resilience topics will continue to be funded through SBE core programs in FY 2019.

[3] In FY 2019, NSF INCLUDES funding is provided through the EHR account.

SBE Funding for Facilities

SBE Funding for Facilities
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Total	**$0.40**	**-**	**$0.40**	**-**	**-**
National Nanotechnology Coordinated Infrastructure (NNCI)	0.40	-	0.40	-	-

For detailed information on individual facilities, please see the Facilities and the Major Research Equipment and Facilities Construction chapters.

Funding Profile

SBE Funding Profile

	FY 2017 Actual Estimate	FY 2018 (TBD)	FY 2019 Estimate
Statistics for Competitive Awards:			
Number of Proposals	4,311	-	4,300
Number of New Awards	1,031	-	920
Funding Rate	24%	N/A	21%
Statistics for Research Grants:			
Number of Research Grant Proposals	3,010	-	3,000
Number of Research Grants	607	-	540
Funding Rate	20%	N/A	18%
Median Annualized Award Size	$113,847	-	$113,800
Average Annualized Award Size	$138,611	-	$138,600
Average Award Duration, in years	2.6	-	2.6

People Involved in SBE Activities

Number of People Involved in SBE Activities

	FY 2017 Actual Estimate	FY 2018 (TBD)	FY 2019 Estimate
Senior Researchers	1,482	-	1,300
Other Professionals	427	-	400
Postdoctoral Associates	167	-	100
Graduate Students	1,521	-	1,400
Undergraduate Students	1,139	-	1,000
K-12 Teachers	-	-	-
K-12 Students	-	-	-
Total Number of People	**4,736**	**-**	**4,200**

Program Monitoring and Evaluation

Workshops and Reports:

- In 2017, the National Academies of Sciences, Engineering, and Medicine (the National Academies), at the request of NSF, appointed an expert committee to examine whether SBE research furthers the mission of NSF and those of other federal agencies and advances the work of business and industry. In its report, *The Value of Social, Behavioral, and Economic Sciences to National Priorities: A Report for the National Science Foundation*[1], the expert committee concludes that the SBE sciences advance the missions of NSF and other federal agencies, and it highlights the many contributions of the SBE sciences to meeting national needs. It presents examples of how SBE research is used by business and industry and has enhanced the U.S. economy. In FY 2018, SBE initiated a strategic planning process that will address the committee's recommendations and will solicit input from the research community, other federal agencies, the National Science Board, and industry.
- In 2016, the National Academies, Committee on National Statistics (CNSTAT), at the request of the National Science Foundation's NCSES, convened a panel to review, assess, and provide guidance on

[1]www.nap.edu/catalog/24790/the-value-of-social-behavioral-and-economic-sciences-to-national-priorities

NCSES's approach to measuring the S&E workforce population in the U.S. Given the evolving data needs of NCSES stakeholders, a priority for the panel was to develop a framework for measuring the S&E workforce that provides flexibility to examine emerging issues related to this unique population, while at the same time allowing for stability in the estimation of key trends. In January of 2018, the Academy panel issued its consensus report, *Measuring the 21st Century Science and Engineering Workforce Population: Evolving Needs*[2], with findings, recommendations, and priorities for improving the relevance, accuracy, timeliness, and cost-effectiveness of S&E workforce data for the next decade and beyond.

Committees of Visitors (COV):

- In FY 2020, COVs will review BCS and SMA.

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

[2]www.nap.edu/catalog/24968/measuring-the-21st-century-science-and-engineering-workforce-population-evolving

DIVISION OF SOCIAL AND ECONOMIC SCIENCES (SES) **$86,680,000**
-$11,190,000 / -11.4%

SES Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change Over FY 2017 Actual Amount	Change Over FY 2017 Actual Percent
Total	**$97.87**	**-**	**$86.68**	**-$11.19**	**-11.4%**
Research	**87.66**	**-**	**79.69**	**-7.97**	**-9.1%**
CAREER	2.46	-	3.74	1.28	52.1%
Education	**1.80**	**-**	**0.50**	**-1.30**	**-72.2%**
Infrastructure	**8.41**	**-**	**6.49**	**-1.92**	**-22.8%**
NNCI	0.40	-	0.40	-	-
Research Resources	8.01	-	6.09	-1.92	-23.9%

SES Summary

SES supports research and related activities that improve understanding of economic, social, and political 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; and broadening participation in the social, behavioral, and economic sciences. Discipline-based programs include economics, political science, and sociology, while interdisciplinary programs support research in 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 the only, source of federal funding for fundamental research, making important investments in the data resources and methodological advances that produce transformative research. In addition, SES research contributes to better understanding of issues related to national security, terrorism, and economic, social, and behavioral well-being.

In general, 74 percent of the SES portfolio is available for new research grants and 26 percent is available for continuing grants.

DIVISION OF BEHAVIORAL AND COGNITIVE SCIENCES (BCS) **$84,950,000**
-$9,800,000 / -10.3%

BCS Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change Over FY 2017 Actual Amount	Percent
Total	**$94.75**	**-**	**$84.95**	**-$9.80**	**-10.3%**
Research	**90.38**	**-**	**83.51**	**-6.87**	**-7.6%**
CAREER	8.23	-	3.63	-4.60	-55.9%
Education	**2.87**	**-**	**0.44**	**-2.43**	**-84.7%**
Infrastructure	**1.50**	**-**	**1.00**	**-0.50**	**-33.3%**
Research Resources	1.50	-	1.00	-0.50	-33.3%

BCS Summary

BCS supports research and related activities that advance fundamental understanding in the behavioral, cognitive, anthropological, neuroscience, and geographic sciences. Strong core programs are complemented by active involvement in competitions that support collaborative and cross-disciplinary projects that increase understanding of mind, brain, and society. 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 in groups, society, 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. 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 anticipate and respond to critical issues in areas such as national security, terrorism, and global change.

In general, 77 percent of the BCS portfolio is available for new research grants and 23 percent is available for continuing grants.

NATIONAL CENTER FOR SCIENCE AND ENGINEERING STATISTICS (NCSES) **$51,190,000**
$0 / 0.0%

NCSES Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change Over FY 2017 Actual Amount	Change Over FY 2017 Actual Percent
Total	**$51.19**	**-**	**$51.19**	**-**	**-**
Infrastructure	**51.19**	**-**	**51.19**	**-**	**-**

NCSES Summary

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 mandated to collect 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 primary responsibility for statistics regarding the S&E 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* and *Women, Minorities, and Persons with Disabilities in Science and Engineering*.

SBE OFFICE OF MULTIDISCIPLINARY ACTIVITIES (SMA) **$23,370,000**
-$3,710,000/ -13.7%

SMA Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change Over FY 2017 Actual Amount	Percent
Total	**$27.08**	**-**	**$23.37**	**-$3.71**	**-13.7%**
Research	**18.56**	**-**	**17.42**	**-1.14**	**-6.1%**
Education	**7.44**	**-**	**5.95**	**-1.49**	**-20.0%**
Infrastructure	**1.08**	**-**	**-**	**-1.08**	**-100.0%**
Research Resources	1.08	-	-	-1.08	-100.0%

SMA Summary

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 crosscutting NSF investments in FY 2019: UtB; cybersecurity, via SaTC; innovation, via I-Corps™; interdisciplinary research and training, via activities such as the SPRF-Fundamental Research (SPRF-FR) and Broadening Participation (SPRF-BP) tracks; and the science of learning core program. 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, such as SBE's Robust and Reliable Science funding activity initiated with a Dear Colleague Letter, which conducted its first competition in FY 2017. All areas of SBE sciences are represented in the SMA portfolio.

In general, 64 percent of the SMA portfolio is available for new research grants and 36 percent is available for continuing grants.

OFFICE OF INTERNATIONAL SCIENCE AND ENGINEERING (OISE) **$48,500,000**
-$460,000 / -0.9%

OISE Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
OISE	**$48.96**	**-**	**$48.50**	**-$0.46**	**-0.9%**

About OISE

OISE is the NSF focal point for international science and engineering activities. OISE's mission is to promote an integrated, Foundation-wide international engagement strategy and manage internationally-focused programs that are innovative and catalytic. OISE focuses on international activities to promote innovation among the U.S. research community through access to international knowledge, infrastructure, and capabilities.

OISE's FY 2019 Budget focuses on three activities: (1) promoting the development of a globally competent U.S. workforce, (2) facilitating and supporting international partnerships and networks to leverage NSF and foreign resources, and (3) providing opportunities for U.S. leadership to shape the global science and engineering agenda. OISE's FY 2019 Budget Request supports these strategies by developing and implementing novel programs such as the International Research Experiences for Students (IRES) and Accelerating Research through International Networks (AccelNet). In addition, OISE provides expert analysis and policy recommendations by leveraging a diverse network of relationships with interagency and international partners.

OISE also manages NSF's overseas offices in Beijing, Brussels, and Tokyo. These offices have been integral to our successful collaborations in the past. However, the impact of physical offices has changed as the world has changed. To ensure NSF is aware of, and has access to, the best minds and facilities, the foundation will transition international engagement to a new model that allows NSF to expand its outreach and cooperation around the globe. The new approach will deploy NSF experts for short-term expeditions to selected areas to explore opportunities for collaboration. This transition means NSF will close the overseas offices by the beginning of FY 2019.

FY 2019 OISE Summary

OISE Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Research	$39.38	-	$36.40	-$2.98	-7.6%
Education	9.47	-	12.00	2.53	26.6%
Infrastructure	0.10	-	0.10	-	-
Total	**$48.96**	**-**	**$48.50**	**-$0.46**	**-0.9%**

Major Investments

OISE Major Investments
(Dollars in Millions)

Area of Investment	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
INFEWS	$1.28	-	$0.90	-$0.38	-29.7%

Summary and Funding Profile

OISE Funding Profile

	FY 2017 Actual Estimate	FY 2018 (TBD)	FY 2019 Estimate
Statistics for Competitive Awards:			
Number of Proposals	299	-	300
Number of New Awards	195	-	150
Funding Rate	65%	-	50%
Statistics for Research Grants:			
Number of Research Grant Proposals	151	-	100
Number of Research Grants	47	-	35
Funding Rate	31%	-	35%
Median Annualized Award Size	$84,370	-	$250,000
Average Annualized Award Size	$318,005	-	$500,000
Average Award Duration, in years	3.5	-	3.0

People Involved in OISE Activities

Number of People Involved in OISE Activities

	FY 2017 Actual Estimate	FY 2018 (TBD)	FY 2019 Estimate
Senior Researchers	386	-	380
Other Professionals	74	-	80
Postdoctoral Associates	31	-	30
Graduate Students	122	-	120
Undergraduate Students	101	-	100
Total Number of People	**714**	**-**	**710**

Program Monitoring and Evaluation

External Program Evaluations and Studies:

- In FY 2018, OISE will fund an evaluation of the IRES program. A request for proposals will be issued by March 2018 and the final results are expected in March 2019.

Committees of Visitors (COV):

- In December 2017, a COV reviewed OISE programs and activities. The COV chair presented the report

to the OISE Advisory Committee (AC) in January 2018. OISE will respond to the COV recommendations by Spring 2018.

- In January 2018, a COV reviewed awards to the National Academies of Sciences, Engineering, and Medicine (the National Academies) Board on International Science Organizations (BISO). BISO's mission is to strengthen science for the benefit of society through U.S. leadership, collaboration, and representation in international scientific organizations and initiatives. BISO provides information about these international scientific organizations and initiatives to the leadership of the National Academies, the National Science Foundation, the Department of State, and other organizations.

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.

OFFICE OF POLAR PROGRAMS (OPP) **$534,540,000**
+$66,690,000 / 14.3%

OPP Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Research	**$119.05**	**-**	**$113.56**	**-$5.49**	**-4.6%**
CAREER	0.50	-	1.24	0.74	146.4%
Long Term Ecological Research (LTER)	2.29	-	3.49	1.20	52.1%
Education	**2.46**	-	**0.79**	**-1.67**	**-67.9%**
Infrastructure	**346.34**	-	**420.19**	**73.85**	**21.3%**
Antarctic Infrastructure Modernization for Science (Construction)	**-**	-	103.70	103.70	N/A
Arctic Research Support and Logistics	45.06	-	39.33	-5.73	-12.7%
IceCube Nutrino Observatory (IceCube)	3.50	-	3.50	-0.00	-0.0%
U.S. Antarctic Facilities and Logistics	215.71	-	193.61	-22.10	-10.2%
U.S. Antarctic Logistical Support	69.28	-	71.00	1.72	2.5%
Geodesy Advancing Geosciences and EarthScope	1.52	-	1.29	-0.23	-14.9%
Seismological Facilities for Advancement of Geoscience and EarthScope	1.70	-	1.26	-0.44	-25.9%
Polar Environment, Safety, and Health (PESH)	6.61	**-**	6.13	-0.48	-7.2%
Facilites Development and Design Total	**2.97**	**-**	**0.37**	**-2.60**	**-87.5%**
Antarctic Infrastructure Modernization for Science (Concept and Design)	2.97	-	0.37	-2.60	-87.5%
Total	**$467.85**	**-**	**$534.54**	**$66.69**	**14.3%**

About OPP

The Office of Polar Programs (OPP) is the primary U.S. supporter of fundamental research in the polar regions. In the Arctic, NSF helps coordinate research planning as directed by the Arctic Research Policy Act of 1984, and the NSF Director chairs the Interagency Arctic Research Policy Committee (IARPC) created for this purpose. In the Antarctic, per Presidential Memorandum 6646, NSF manages all U.S. activities as a single, integrated program, making Antarctic research possible for scientists supported by NSF and by other U.S. 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 (USAP) research activity supported 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 System.

OPP supports investments in research and education and provides support for research infrastructure, such as permanent stations and temporary field camps in the Antarctic and the Arctic. OPP's FY 2019 Budget Request is influenced by three key priorities: (1) supporting critical facilities that enable frontier research in the Earth's polar regions; (2) maintaining strong disciplinary programs that provide a base for our investments in cross-disciplinary system science programs and; (3) maintaining U.S. research community activities in polar system science. As part of priority one, OPP will start the construction phase of the multi-year Antarctic Infrastructure Modernization for Science (AIMS) project. OPP will also prioritize investment in two of the Big Ideas: Navigating the New Arctic where OPP leads NSF efforts, and Windows on the Universe where OPP invests in underpinning activities. All of these priorities reflect opportunities for

fundamental scientific discovery uniquely possible in polar regions, as well as studies to investigate the causes and future trajectory of environmental and ecosystem changes now being observed at the poles that could impact global systems. This work will implement the Foundation's lead-agency role in facilitating the Nation's investment in polar science.

In addition to shared cross-directorate basic research objectives, OPP investments will be guided by recent sponsored studies to identify priority areas and ensure effective polar research programs:

- For the Arctic, IARPC's *Arctic Research Plan: FY 2017-2021*[1], and the World Meteorological Organization's *Year of Polar Prediction Implementation Plan*[2] inform science investment priorities. Efforts to build an integrated research capacity to address the potential opportunities and challenges of Arctic change for the Nation's security and economics and well-being of Arctic residents will continue.
- For the Antarctic, the 2015 National Research Council report *A Strategic Vision for NSF Investments in Antarctic and Southern Ocean Research*[3] inform science investment priorities. Specifically, in 2018, OPP initiated support of a five-year deep-field program to study the Thwaites Glacier region that was the highest priority in that study. The Thwaites program will be jointly funded, including shared logistics, with the National Environment Research Council of the U.K.

OPP Funding for Facilities

OPP Funding for Facilities
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Total	**$346.34**	**-**	**$420.19**	**$73.85**	**21.3%**
Arctic Research Support and Logistics	45.06	-	39.33	-5.73	-12.7%
Geodesy Advancing Geosciences and Earthscope (GAGE)	1.52	-	1.29	-0.23	-14.9%
IceCube Neutrino Observatory	3.50	-	3.50	0.00	-
Seismological Facilities for Advancement of Geosciences and Earthscope (SAGE)	1.70	-	1.26	-0.44	-25.9%
U.S. Antarctic Facilities and Logistics	215.71	-	193.61	-22.10	-10.2%
Polar Environment, Safety, and Health (PESH)	6.61	-	6.13	-0.48	-7.2%
AIMS Concept and Design	2.97	-	0.37	-2.60	-87.5%
AIMS Construction	-	-	103.70	103.70	N/A
U.S. Antarctic Logistical Support	69.28	-	71.00	1.72	2.5%

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

[1]www.iarpccollaborations.org/uploads/cms/documents/iarpc_arctic_research_plan_2017-2021.pdf
[2]www.polarprediction.net/documents/implementation-science-plans/
[3]www.nap.edu/catalog/21741/a-strategic-vision-for-nsf-investments-in-antarctic-and-southern-ocean-research

Funding Profile

OPP Funding Profile

	FY 2017 Actual Estimate	FY 2018 (TBD)	FY 2019 Estimate
Statistics for Competitive Awards:			
Number of Proposals	707	-	650
Number of New Awards	226	-	190
Funding Rate	32%	-	29%
Statistics for Research Grants:			
Number of Research Grant Proposals	673	-	620
Number of Research Grants	196	-	160
Funding Rate	29%	-	26%
Median Annualized Award Size	$152,717	-	$140,400
Average Annualized Award Size	$199,542	-	$183,500
Average Award Duration, in years	2.6	-	2.6

People Involved in OPP Activities

Number of People Involved in OPP Activities

	FY 2017 Actual Estimate	FY 2018 (TBD)	FY 2019 Estimate
Senior Researchers	895	-	800
Other Professionals	530	-	500
Postdoctoral Associates	102	-	90
Graduate Students	328	-	300
Undergraduate Students	215	-	200
K-12 Teachers	-	-	-
K-12 Students	-	-	-
Total Number of People	**2,070**	**-**	**1,890**

Program Monitoring and Evaluation

Science and Technology Policy Institute (STPI) Reports:
In 2017, OPP initiated an "analysis of alternatives" study of its airlift requirements in both polar regions. It is an analysis to help refine options and inform management decisions regarding the NSF-owned LC-130 aircraft. This study is expected to be completed in mid-2018.

Workshops and Reports:
OPP sponsored several studies over the past seven years to gather direction from the polar science community and to help plan for effective research programs into the future. The findings and recommendations from these reports continue to influence and drive OPP funding and investment policy decisions as described above. In addition, the execution of the merit review process by OPP has been recently reviewed by the GEO Advisory Committee.

Committees of Visitors (COV):

- In FY 2016, separate COVs were conducted to review the Antarctic Sciences Section (ANT) and the

Arctic Sciences Section (ARC). The COV report for each section was presented to the GEO Advisory Committee, which convened in October of 2016. The COVs found that the programs under review were well-managed by each section.

- The next COVs for ANT and ARC will be conducted in FY 2020.

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.

ANTARCTIC INFRASTRUCTURE MODERNIZATION FOR SCIENCE (AIMS) $103,700,000

Appropriated Funding Requirements
for the Antarctic Infrastructure Modernization for Science Project
(Dollars in Millions)

	FY 2019 Request	FY 2020 Estimate	FY 2021 Estimate	FY 2022 Estimate	FY 2023 Estimate	Total Project Cost
AIMS	$103.70	$75.00	$75.00	$60.00	$41.25	$354.95
Total	**$103.70**	**$75.00**	**$75.00**	**$60.00**	**$41.25**	**$354.95**

The Antarctic Infrastructure Modernization for Science (AIMS) construction project is initiated in FY 2019 with an investment of $103.70 million. This amount is the first year in a multi-year funding profile with an estimated total project cost of $354.95 million. In accordance with NSF's No Cost Overrun policy, NSF is currently planning within the estimated Total Project Cost (TPC) following the Preliminary Design Review. NSF will finalize the total project cost and the associated scope, schedule, and funding profile at time of award; benefiting from both the Final Design Review and the Independent Cost Estimate.

FY 2019 funds will be used to complete the designs of all construction components, begin the site preparation work for the backbone utilities and the initial buildings, such as the Vehicle and Equipment Operations Center, and procure the first phases of construction materials. The construction of the remaining buildings that comprise AIMS (descriptions provided below), will be supported by funding in subsequent fiscal years. The AIMS Project is currently anticipated to take approximately 8 to 10 years to complete; a further refined schedule will be developed as part of the final design phase.

The total cost of the AIMS construction project will be funded within the R&RA account.

The AIMS project will replace major facilities at McMurdo Station, Antarctica, one of three stations that comprise the U.S. presence in Antarctica, to meet anticipated science support requirements for the next thirty-five to fifty years. The project will help ensure enduring U.S. leadership and influence in this strategic region. It will also support critical scientific research and capabilities such as nuclear test detection, earthquake monitoring, and real-time weather data ingestion for global forecasting.

McMurdo Station's main purpose is to support both near- and deep-field science in Antarctica including activities at Amundsen-Scott South Pole Station. AIMS will enable faster, more streamlined logistical and science support by co-locating or consolidating warehousing, skilled trades work, and field science support where field projects are prepared for movement into the field, into four connected enclosed buildings. AIMS will also provide necessary up-graded utilities to support these facilities. The AIMS scope described below was determined to be the most efficient and cost-effective combination of work packages in support of science operations at McMurdo.

Baseline History
In 2011, the Office of Science Technology and Policy and NSF convened a Blue Ribbon Panel (BRP) to evaluate the U.S. Antarctic Program (USAP) logistical enterprise. The BRP was asked to conduct a review to discern any discrepancies with future science support needs, to identify opportunities for increased efficiencies, and to propose corrective actions that address the scientific opportunities articulated by an earlier 2011 National Research Council report entitled *Future Science Opportunities in Antarctica and the Southern Ocean*. The BRP report made numerous recommendations regarding maintaining and enhancing the U.S.'s world-class science program in Antarctica. The report offered 84 implementing actions that target three areas: (1) efficient and cost-effective support of science, (2) maintaining high standards of safety, and

(3) flexibility of support infrastructure and logistics to facilitate evolving science areas in the future.

NSF responded to the BRP report by immediately addressing issues of safety, implementing operational efficiencies which resulted in immediate return on investment, and developing long-term plans for each of the three year-round U.S. stations; Palmer, Amundsen-Scott South Pole and McMurdo. The AIMS project is a pivotal component of the McMurdo Station Master Plan with a specific focus on the primary core functions of this critical logistics hub.

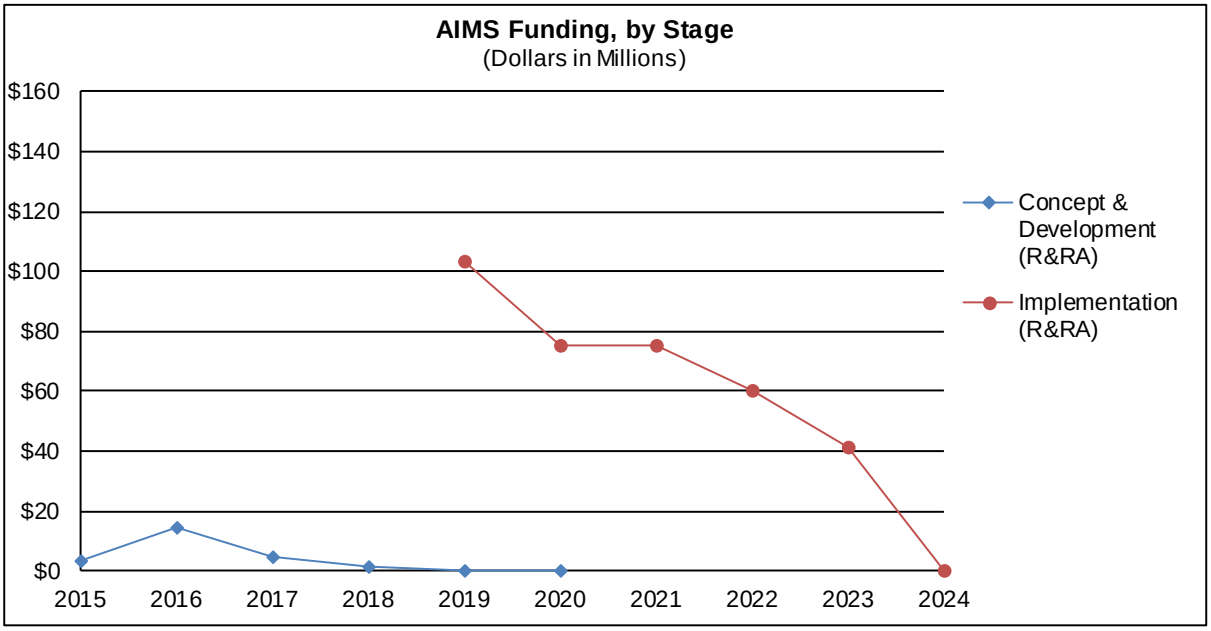
The scope of AIMS includes:

1) Core Facility, including:
   a. Central Services Facility: mission command and control, food service, warehousing, and materials handling,
   b. Continuity of Operations and Emergency Facilities: fire station, medical clinic, emergency berthing, and recreation,
   c. Field Science Support Facility,
   d. Station Operating Support facility: industrial trades shops and supplies/materials, and
2) Utilities: domestic and firefighting water, power, waste water, heating distribution, IT, and communications,
3) Vehicle and equipment operations center (VEOC), and
4) A permanent lodging facility that will also be utilized to accommodate the increased workforce required for AIMS construction.

Total Funding Requirements for AIMS

(Dollars in Millions)

	Prior Years	FY 2017 Actual	FY 2018 Estimate	FY 2019 Request	ESTIMATES FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
R&RA:									
Concept and Development	$18.20	$2.97	$1.80	$0.37	-	-	-	-	-
Implementation	-	-	-	103.70	75.00	75.00	60.00	41.25	-
TOTAL	**$18.20**	**$2.97**	**$1.80**	**$104.07**	**$75.00**	**$75.00**	**$60.00**	**$41.25**	**-**



Note: Outyear (FY 2020 through FY 2024) Implementation funding reflects current estimates.

Management and Oversight

AIMS will be accomplished under the Federal Acquisition Regulations (FAR) via an existing contract to Leidos Innovation Corporation as the current Antarctic Support Contractor. OPP will provide technical oversight and the Division of Acquisition and Cooperative Support (DACS) will provide contract oversight. Although funded through the R&RA account, not the MREFC account, AIMS is considered a major facility under the definitions contained in the 2017 American Innovation and Competitiveness Act (AICA). Therefore, all of NSF's current oversight requirements will apply, including project management assistance and oversight from the Large Facilities Office (LFO), with due consideration of award through a FAR-based contract.

Under an interagency agreement, the Defense Contract Management Agency negotiates, manages, and audits Leidos' forward pricing rate agreements and associated business systems in place for monitoring and ensuring effective performance.

Routine oversight activities include, but are not limited to:

- Integrated master scheduling and project management oversight;
- Monthly program management reviews;
- Earned value management on discrete projects;
- Configuration and change review boards for cost and scope control management;
- Contractor performance management; and
- Internal controls for finance and property management, including A-123 compliance.

The Naval Facilities Engineering Command Pacific provided expert engineering advice during the design phase of the project. NSF intends to continue to use the services of a third-party expert for engineering advice during the construction phase of AIMS.

Leidos will initiate the acquisition process by performing market research leading to a request for qualifications for construction. All steps of the acquisition process will be subject to review by NSF and appropriation of funds. Prior to an award for construction, the AIMS project will complete a Final Design Review, which is anticipated to be held in fall 2018.

The AIMS project will entail a combination of design/bid/build (DBB) and design/build (DB) subcontracts. General contractors asked to submit proposals will be pre-qualified, and a single general contractor is expected to complete all four projects under a firm fixed price or an alternative contract type that the government deems appropriate for the particular activity. NSF will take an active role in overseeing all efforts to ensure the government's interests are achieved.

Reviews

- Conceptual Design Review (CDR): CDR was conducted March 31-April 2, 2015. The NSF program staff concurred with the external panel's conclusion that the project execution plan and technical design package met, and in some cases exceeded, the requirements of the Conceptual Design Phase.
- Preliminary Design Review (PDR): PDR was conducted December 5-8, 2016. The external panel found that the project execution plan and the technical design package were both well-developed for the PDR phase and recommended that the project was ready to proceed to the Final Design Phase. Following NSF deliberations, the National Science Board passed a resolution (NSB-2017-20) authorizing NSF to include AIMS in a future budget request.
- Final Design Review (FDR): FDR is anticipated in the fall of 2018 to ensure that anticipated project costs remain realistic and that no unforeseen events have arisen prior to awarding the sub-contract in mid FY 2019. The NSF will ensure an independent cost estimate is conducted during FY 2018.
- Following Board authorization, the project transitioned from the PDR milestone into the final design phase.

Project Status

Leidos has begun pre-acquisition tasks required for the FDR milestone review, including market research and an industry day presentation in August 2017. Designs for all components of AIMS have been completed to an appropriate level for the purpose of preparing the request for qualifications.

Cost and Schedule

FY 2019 funds will be used to complete the designs of all construction components, begin the site preparation work for the backbone utilities and the initial buildings such as the Vehicle and Equipment Operations Center, and procure the first phases of construction materials. Construction of the core facility will be supported by funding in the subsequent fiscal years. The phasing plan allows for managed impact on science support during construction, as well as continuity of operations in the event that subsequent funding is disrupted. Each successive phase must be fully funded to start and finish that phase so that if subsequent project funding is disrupted, the station will remain fully capable for USAP operations. The AIMS Project is currently anticipated to take approximately 8 to 10 years to complete; a further refined schedule will be developed as part of the final design phase.

Risks

Construction phasing milestones are timed such that confidence in relevant aspects of project readiness is assessed at appropriate intervals. Scope management options have been identified to ensure that the project proceeds only if it can be shown that continued investment is warranted, or that the project phase can be executed successfully. Before each phase begins, sufficient funding must be secured to ensure that that phase can be successfully completed. Should the required funding not be secured, the NSF may elect to postpone the phase or cancel the program altogether. This off-ramp assessment is critical to ensure that the station is able to meet ongoing and future science support requirements. Existing structures cannot be demolished unless the funding to construct the functional replacement is secured.

Leidos developed a bottom-up cost estimate for AIMS by integrating the construction cost estimate from their cost estimating consultant and coupled it with Leidos' estimate of logistics and support costs. The consultant estimators were retained for the construction cost estimate because of their extensive experience

estimating commercial construction globally. Leidos has the most extensive understanding of ancillary costs to support construction in Antarctica. The cost estimating and risk analysis methodology and documentation were verified for compliance with the Government Accountability Office Cost Estimating and Assessment Guide by an independent cost assessment conducted by a private contractor under contract through LFO.

The cost estimate includes a provision for inflation of 2.5 percent per year through 2026. The risk register used to develop the contingency budget is associated with known project risks: primarily events and factors that affect labor and material costs as well as construction support considerations such as the station capacity for the required number of personnel and findings related to site conditions. It also accounts for logistical risks such as accommodating critical supplies that miss the annual cargo vessel that then must be delivered through costlier means. In addition, the contingency budget also accounts for schedule risk associated with weather or other events that can create materials, equipment, and labor shortages due to delivery delays. For example, if manufacturers miss the deadline for the annual supply ship, premium air freight costs will be incurred to get supplies to McMurdo on time. Weather poses the greatest known risk to the schedule.

A primary risk mitigation tool is the design/build contract mechanism itself where the contracted firm is able to make tradeoffs within the awarded budget that do not adversely affect the final outcome. Finally, a time-phased, science-prioritized scope management plan has also been developed to identify scope that may be removed to stay within the total project cost without affecting the overall project's objectives, as well as accommodating opportunities that may arise if risks are not fully realized.

Future Operations Costs

Implementing AIMS will provide a material reduction of the cost to maintain and operate McMurdo station including an estimated $3.50 million in fuel and $2.40 million in labor per year (based on current costs). Fuel savings of about 340,000 gallons per year will be possible due to greater energy efficiency of the consolidated station made possible with AIMS. Labor savings will accrue mainly through the efficiency of consolidated warehousing (with 90 percent reduction of exterior storage), co-locating work areas, and lowering residence time of science projects, also made possible by AIMS.

Image 1: *Artist's rendering of AIMS Core Facility*

INTEGRATIVE ACTIVITIES (IA) **$536,720,000**
+$116,450,000 / 27.7%

IA Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Percent
Convergence Accelerator: The Future of Work at the Human-Technology Frontier	-	-	$30.00	$30.00	N/A
Convergence Accelerator: Harnessing the Data Revolution	-	-	30.00	30.00	N/A
Evaluation and Assessment Capability[1]	[4.71]	-	3.00	-1.71	-36.3%
EPSCoR	162.80	-	160.00	-2.80	-1.7%
Graduate Research Fellowship Program	160.79	-	135.36	-25.43	-15.8%
Growing Convergence Research	-	-	16.00	16.00	N/A
HBCU Excellence in Research	-	-	10.00	10.00	N/A
INSPIRE	6.48	-	-	-6.48	-100.0%
Major Research Instrumentation	76.19	-	75.00	-1.19	-1.6%
Mid-scale Research Infrastructure	-	-	60.00	60.00	N/A
NSF 2026	-	-	6.50	6.50	N/A
NSF INCLUDES	1.91	-	-	-1.91	-100.0%
Planning and Policy Support	2.09	-	2.50	0.41	19.6%
Research Experiences for Undergraduates	0.64	-	-	-0.64	-100.0%
Research Investment Communications	3.47	-	3.47	-	-
Science and Technology Center Administration	0.16	-	0.15	-0.01	-6.3%
Science and Technology Policy Institute	4.74	-	4.74	-	-
STAR Metrics	1.00	-	-	-1.00	-100.0%
Total	**$420.27**	**-**	**$536.72**	**$116.45**	**27.7%**

[1]Evaluation and Assessment Capability funding for FY 2017 Actual is displayed for comparability. FY 2017 activities were supported by the Other Program Related Administration. See the Program Accounts: R&RA and EHR chapter for more information.

The FY 2019 Budget Request for IA is $536.72 million. This request highlights NSF's continuing emphasis on building capacity across the research and education enterprise.

About IA

The activities supported by IA expand NSF's capacity for discovery and innovation through the formation of new ideas and concepts, experimentation, and assessment. IA has five main goals:

- To strengthen the alignment of NSF's activities with its mission;
- To enhance NSF's ability to solicit, review, award, and manage a portfolio of frontier projects;
- To develop high-performance analytics and tools that reveal new insights into NSF's award portfolio and inform policies and practices;
- To advance research infrastructure that will enable discovery across U.S. academic institutions; and
- To promote an inclusive national STEM enterprise that supports the development of STEM talent.

FY 2019 Activities

Convergence Accelerators

- NSF is initiating a new organizational structure approach called Convergence Accelerators to align its processes and operations with contemporary science and engineering research and education. The first two Convergence Accelerators will accelerate research advances for the Future of Work at the Human-Technology Frontier (FW-HTF) and Harnessing the Data Revolution for 21st-Century Science and Engineering (HDR) Big Ideas by facilitating convergent and translational activities in FW-HTF and HDR, especially through creation and leveraging of external partnerships. These Convergence Accelerators will complement HDR and FW-HTF research investments by engaging NSF directorates and offices in existing and new NSF programs that are aligned with the goals of the HDR and FW-HTF Big Ideas.

Convergence Accelerator: The Future of Work at the Human-Technology Frontier (FW-HTF):

- To promote global leadership in work productivity and quality, the FW-HTF Convergence Accelerator aims to speed up the progress of discovery and innovation at the nexus of humans, technology, and work. It is critical that emerging technologies, like artificial intelligence and robotics, augment human performance and benefit society. It is important to address the new skills that will be needed to work with new technologies in new industries and sectors in order to enable workers to migrate from old to new jobs. Partnerships with other federal agencies, industry, foundations, and international organizations will support translational aspects of convergence research, prototyping in workplace testbeds, and living laboratories, as well as promote needs-based, technology-mediated job training and retraining.

Convergence Accelerator: Harnessing the Data Revolution for 21st-Century Science and Engineering (HDR):

- Access to the next level of discovery relies on translating complex data from observations, experiments, and simulations into knowledge and eventual action. Individuals, scientific and social communities, industry, and the Nation will benefit from new data-rich capabilities, infrastructure, and services. The HDR Convergence Accelerator will surface a series of real-world, data-driven challenges requiring partnerships with other federal agencies, private industry, and international organizations to achieve maximum impact. For example, the HDR Convergence Accelerator will expand ongoing partnerships with cloud computing vendors and establish new partnerships to gain access to the most cutting-edge hardware on which the research community can develop new algorithms and solve complex problems. It will jumpstart partnerships with other federal agencies, private industry, and non-profits to gain access to interesting data and serious data challenges on which multi-disciplinary and multi-sector "tiger teams" can work to make significant advances in the near and medium terms. It will lead a change in the form and nature of collaborations required to deepen and strengthen the preparation of the next-generation workforce that effectively engages with data. Achieving these goals will position the United States as a global leader in data-driven discovery and innovation.

Evaluation and Assessment Capability (EAC)

- EAC supports agency-wide program evaluations; improvements in data quality, and access to data and data analytics tools; and activities that inform organizational learning in the performance of NSF programs, policies, and day-to-day operations.
- A detailed discussion of EAC related and co-led activities is found later in the Program Monitoring and Evaluation section of this narrative.

EPSCoR

- EPSCOR funding in FY 2019 will catalyze key research themes, including national research priorities within and among EPSCoR jurisdictions that engender knowledge creation, broaden participation in science and engineering, and strengthen the research opportunities available to early career faculty.

GRFP

- GRFP invests in the STEM human capital necessary to ensure the Nation's leadership in advancing discovery and innovation in science and engineering. GRFP selects, recognizes, and financially supports graduate students with demonstrated high potential for excellence in STEM and in their chosen careers. Applications are welcome from students in all STEM disciplines supported by NSF and in STEM interdisciplinary areas, including STEM education. Fellows have opportunities for international research through Graduate Research Opportunities Worldwide (GROW) and federal internships through Graduate Research Internship Program (GRIP).
- IA provides 50 percent of NSF's funding for GRFP, with the remainder provided by EHR.
- For additional information on GRFP, see the discussion on Major Investments in STEM Graduate Education narrative in the NSF-Wide Investments chapter.

Growing Convergence Research (GCR)

- The GCR activity answers extremely challenging, transdisciplinary research questions raised by specific compelling problems. The unifying characteristics of these problems are that: (a) if successfully answered, they are likely to have a large impact, either on fundamental understanding in science and engineering or on our ability to meet pressing societal challenges, or both; and (b) they require the integration of knowledge, tools, and ways of thinking from multiple disciplines. The GCR investment engages communities to identify the most promising convergence research areas, incubates efforts to tackle these through exploratory funding, and supports those that demonstrate the potential for significant progress with longer-term funding. In addition to supporting science and engineering research, GCR aims to grow the next generation of convergence researchers. The potential impact of GCR transcends specific research areas as it empowers the scientific enterprise to quickly and effectively adapt and respond to the rapidly changing national and global scientific and technological landscapes.

Historically Black Colleges and Universities – Excellence in Research (HBCU-EiR)

- HBCU-EiR: The HBCU-EiR program focuses on improving the research capacity and competitiveness of HBCUs by providing additional support for research at these institutions. IA co-funds HBCU-EiR awards with NSF's science and engineering directorates. This program was initiated in FY 2017. HBCU-EiR was formally announced with a track in the HBCU-Undergraduate Program solicitation and a first set of awards will be made in FY 2018.

Integrated NSF Support Promoting Interdisciplinary Research and Education (INSPIRE)

- INSPIRE: In FY 2017, this pilot activity ended and a new funding mechanism encompassing elements of INSPIRE was developed, Research Advanced by Interdisciplinary Science and Engineering (RAISE). The RAISE mechanism supports bold, potentially transformative interdisciplinary research that transcends the scope of any individual program. RAISE guidelines are published in the NSF Proposal and Award Policy Procedures Guide and the funding mechanism is available to any researcher conducting transformational, interdisciplinary research in fields that NSF supports. Dedicated IA co-funding has been eliminated. Each directorate will support bold, potentially transformative interdisciplinary research through the RAISE mechanism, coordinating with other directorates, as necessary.

Major Research Instrumentation (MRI)

- The MRI program catalyzes new knowledge and discoveries by empowering the Nation's scientists and engineers with state-of-the-art research instrumentation. The MRI program supports instrument acquisition or development, across all fields of NSF-supported research. It supports research-intensive learning environments that promote the development of a diverse workforce, and it facilitates academic and private sector partnerships.

Mid-scale Research Infrastructure (Mid-scale)

- NSF's science and engineering activities rely increasingly on infrastructure that is diverse in space, cost, and implementation time. Many important research questions require instrumentation and other infrastructure that fall in the gap between the scope of the MRI program and the level of activities supported by the MREFC account. To address this gap and to create opportunities for essential science, the Mid-scale program will invest in instrumentation and other infrastructure projects that require between $4 million and $70 million in NSF-funding. The types of project supported will span the range from expensive but relatively straightforward acquisitions, such as certain types of cyberinfrastructure, to complex one-of-a-kind instruments that require significant design and development phases prior to their implementation. Separate tracks within the Mid-scale program will fund acquisition, design/development, and implementation. When needed, both proposal review and post-award management will include appropriate design reviews involving external experts, with projects advancing to the implementation stage when they have demonstrated design readiness. The Mid-scale program will leverage national and international partnerships between NSF and other organizations, public and private, where appropriate to advance infrastructure for basic research.

NSF 2026 Fund

- The NSF 2026 Fund, in recognition and celebration of the Nation's 250th anniversary, will invest in bold research questions that are large in scope, innovative in character, originate outside any particular directorate, and require a long-term commitment. Just as NSF recently developed its first set of Big Ideas, NSF 2026 will set up and sustain mechanisms that will engage the research community in surfacing the next set. Grand challenge initiatives that require an investment horizon of about 10 years will be identified through an "Idea Machine," which includes broad community input through crowd sourcing, blue ribbon panels, ideas labs, and other mechanisms. Transcending established scientific structures and going beyond standard operating procedures, NSF 2026 intends to ensure continuous exploration at the frontiers of discovery and innovation. NSF 2026 will support portfolio analysis, synthesis, and evaluations of NSF as well as NSF's 10 Big Idea activities ($500,000); identifying grand challenge opportunities ($2.0 million); and high-risk, high-reward research activities ($4.0 million).

NSF INCLUDES

- The goal of NSF INCLUDES is to develop a talented, innovative, and capable science and engineering workforce that reflects the diversity of the Nation. If the United States is to remain the world leader with respect to innovations and discoveries in STEM, it must identify and develop talent from all sectors of society to become tomorrow's STEM professionals. NSF INCLUDES, which began in FY 2016, is expected to continue through FY 2025. FY 2019 funding for NSF INCLUDES will be made through the EHR account.

Planning and Policy Support (PPS)

- PPS supports select NSF-wide policy and planning activities. PPS supports annual agency awards for outstanding achievement in science and technology (the Vannevar Bush Award, Public Service Award, Alan T. Waterman Award, and National Medal of Science), and summer science internship programs that target STEM students from underrepresented groups. PPS invests in collaborations with the

National Academies, including the Government University-Industry Research Roundtable (GUIRR),[1] and the Committee on Science, Engineering, Medicine, and Public Policy (CoSEMPuP).[2]

- Beginning in FY 2019, PPS will support NSF's Proposal Management Efficiency (PME) activity, which moves from the Other Program Related Administration funding source of Organizational Excellence activities to the IA budget line in FY 2019. PME supports activities such as the NSF biennial survey of investigators and reviewers.

Research Investment Communications (RIC)

- RIC is a leading-edge communications effort that is essential for public awareness and broad support of science and engineering. RIC supports the creation of products and processes through traditional and social media platforms that communicate the impacts of NSF's investments in STEM for discovery, national security, and economic competitiveness to policy makers, the media, and the general public.

Science and Technology Centers: Integrative Partnerships (STC) program

- Funding displayed on the Research Experiences for Undergraduates (REU) funding line in the above table represents FY 2017 funding of REU supplements at STCs.
- The 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 among academia, industry, national laboratories, and government. These collaborations create synergies that enhance the training of the next generation of scientists, engineers, and educators; and the creation of job opportunities. STCs have impressive records of research achievements, especially because of their strong partnerships with industry. IA provides support for post-award management and oversight of the existing centers. Out-year commitments to centers with existing awards that extend through FY 2019 are funded by the relevant managing directorates.
- For additional information on STCs, see the discussion on NSF Centers narrative in the NSF-Wide Investments chapter.

Science and Technology Policy Institutes (STPI)

- STPI is a Federally Funded Research and Development Center (FFRDC) sponsored by NSF on behalf of the White House Office of Science and Technology Policy (OSTP).

Science and Technology for America's Reinvestment: Measuring the Effect of Research on Innovation, Competitiveness, and Science (STAR METRICS)

- STAR METRICS was an interagency pilot activity that represented a new approach to developing information on how NSF and other federal Research and Development (R&D) investments affect the innovation ecosystem. Funding was eliminated in FY 2018, as this pilot activity had served its purpose.

Program Monitoring and Evaluation

Workshops and Reports:

- In FY 2017, IA funded a study of Reproducibility and Replicability in Science, to be conducted by the National Academies.[3] The study report will describe examples of effective practices, identify gaps in knowledge, and consider the roles of researchers, professional societies, journals, universities and other research institutions, and funders in advancing reproducibility and replication. The report will include recommendations for advancing reproducibility and replication in research. The study was requested

[1]GUIRR webpage (http://sites.nationalacademies.org/pga/guirr/index.htm).
[2]CoSEMPuP webpage (http://sites.nationalacademies.org/pga/cosepup/index.htm).
[3]NSF-1743856, http://sites.nationalacademies.org/dbasse/bbcss/reproducibility_and_replicability_in_science/index.htm.

by Congress in the American Innovation and Competitiveness Act of 2017.[4] Completion is anticipated in FY 2019.

- In FY 2016, IA co-funded a study on Sexual Harassment in the Scientific and Technical Workforce and its Effects on the Careers of Scientists, Engineers, and Medical Professionals.[5] This study will be conducted by the National Academies and is also funded by several other partners: the National Institutes of Health (NIH), National Aeronautics and Space Administration (NASA), National Institute of Standards and Technology (NIST), National Oceanic and Atmospheric Administration (NOAA), and three private foundations. The study will examine sexual harassment in science, engineering, and medical programs on college and university campuses and the efficacy of institutional responses. A goal is to facilitate efforts to end sexual harassment in science, engineering, and medicine and to reduce the negative impacts these behaviors may have on the under-representation of women in these fields. Completion of the study is anticipated in summer 2018.

Committees of Visitors (COV):

- In 2017 and 2018, none of the major IA programs were scheduled to hold a COV.
- In 2019, a COV will review the EPSCoR program.
- In 2020, a COV will review the Science and Technology Centers: Integrative Partnerships program and the Major Research Instrumentation program.

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.

Evaluation and Assessment Capability Related Activities

EAC was established to provide NSF with enhanced capability to operate from a basis of evidence in program and policy decisions; to more consistently assess the impacts of its investments; and to establish a culture of evidence-based planning and policy-making at NSF. EAC has been responsible for establishing mechanisms for NSF-wide leadership and coordination in program and portfolio evaluation, providing expert support and resources for data collection, integration, and management, and improving NSF-wide evaluation capacity.

In FY 2017, EAC continued work on 12 evaluation projects. Three are EAC-led activities; nine are collaborative projects, including evaluation/monitoring contracts with external entities, that are conducted with the lead directorates of the programs being evaluated. Each of these projects is summarized below.

EAC-led activities:

- Broader Impacts (BI). This study focuses on the nature of BI evidence in proposals, review panel summaries, and annual reports. Findings from this ongoing project continue to inform training and policies on the use of BI in NSF-funded research.
- National Academies of Sciences, Engineering, and Medicine (the National Academies). The purpose of this project is to assess the impact of NSF-funded studies and workshops convened by the National Academies. Using data provided by the National Academies and information gleaned from public websites, EAC is analyzing the number of report downloads, mention of the National Academies studies in publications and legislation, and the influence of such studies on NSF program solicitations. This work is ongoing and will be updated as NSF funds new awards to the National Academies.
- Patents. This study examines patent data from the U.S. Patent and Trademark Office (USPTO) for links to NSF awards. The results, such as time between the award of the grant and the subsequent patent,

[4]Public Law 111-329, www.congress.gov/114/plaws/publ329/PLAW-114publ329.pdf.
[5]NSF-1644492, http://sites.nationalacademies.org/pga/cwsem/shstudy/index.htm.

provide insights into the potential economic impacts of NSF investments. This work is ongoing; the comparison is periodically updated.

EAC-collaborative program evaluations and studies:

- Broadening Participation (BP). This study examines the types and impacts of BP activities across NSF programs that do not have BP as their primary objective. (BP Focused Programs and BP Emphasis Programs are listed in the Summary Tables.) It conducts empirical investigations of BP issues mentioned in proposals or through BP implementation research in annual and final reports. The results of this study will allow NSF to document, assess, and share evidence-based cases of BP for promoting innovation and discovery. Results are anticipated in FY 2018. This study is co-funded with EHR.
- Data Asset Inventory. This study will develop an inventory and assessment of the data assets currently available to support inquiry of NSF investments in human capital, particularly graduate education (excluding GRFP) and workforce development. The overarching purpose is to determine if data elements can be added to ongoing collections or standardized across collections to reduce the burden of future monitoring and evaluation efforts. Results are anticipated in FY 2018. This study is co-funded with EHR.
- GRFP. This activity encompasses the development of a data collection system that can be used to describe the fellows' graduate school experiences and track career outcomes. This system, with a potential expansion to describe the education and career trajectories of all graduate students funded by NSF, is expected to be in place in FY 2020. This study is co-funded with EHR.
- Research Experience for Undergraduates (REU). The primary purpose of this effort is to design, build, pilot, test, and analyze options for a web-based longitudinal data collection system for following the career trajectories of REU Site participants. This data collection effort will lay the groundwork for future analyses of participant outcomes. Results are anticipated in FY 2019. This study is co-funded with EHR.
- Technical assistance for NSF INCLUDES. The purpose of this project is to offer evaluation-related technical assistance to aid the initial development of design, implementation, and assessment support activities for the NSF INCLUDES Design and Development Launch Pilots. Technical assistance services may consist of, but are not limited to, coaching and training, experienced consultation/facilitation, tools and resources, technology, and peer learning. This technical assistance will be provided until the end of FY 2019. This study is co-funded with EHR, CISE, ENG and SBE.
- Evaluation of NSF INCLUDES. This comprehensive, developmental, program-level evaluation provides formative feedback to support continuous learning and improvement during the inaugural phase of the NSF INCLUDES initiative. It will assess the processes and progress of all Launch Pilots, Alliances, and Coordination Hub projects. Results from this developmental phase of the project are anticipated in FY 2019. This study is co-funded with EHR, CISE, GEO and MPS.
- NSF Innovation Corps (I-Corps™) Teams Program. This longitudinal evaluation of I-Corps™ teams focuses on the impact of the program on the participants as well as their academic institutions. The results will shed light on how I-Corps™ extends the focus of the researchers beyond the research environment. Results are anticipated in FY 2018. This study is co-funded with ENG.
- Secure and Trustworthy Cyberspace (SaTC). This study builds on STPI findings from a review of historical data from investments in cybersecurity from 2008 to 2011. The primary emphasis of the evaluation will be on data from the inception of SaTC in FY 2012 to the present. An understanding of how and in what ways SaTC makes collective progress toward its talent development goals and objectives will inform the use of these findings to refine existing and future SaTC program level activities. Results are anticipated before the end of FY 2019. This study is co-funded with CISE.
- Science, Engineering, and Education for Sustainability (SEES). This evaluation of the SEES portfolio seeks to measure the success in terms of: (1) the development of new knowledge and concepts that advance the overarching goal of a sustainable human future; (2) new and productive connections made

among researchers in a range of disciplines; and (3) the development of a workforce capable of meeting sustainability challenges. Results are anticipated in FY 2018. This study is co-funded with GEO.

In FY 2017, two new EAC-led studies were initiated as well as three new collaborative evaluations, each of which is summarized below.

EAC-led studies:

- Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS). The purpose of this study is to determine to what extent and how the scientific community has addressed the interdisciplinary nature of the three focal systems – food, energy, and water – in responses to the FY 2015 and FY 2016 NSF INFEWS solicitations. This analysis will inform changes to the next solicitation. Results are anticipated in FY 2018.
- Intergovernmental Personnel Act (IPA). The purpose of this project is to assess the effect of the policy change requiring a mandatory 10 percent institutional cost share on NSF's IPA program. Results from the pilot, expected before the end of FY 2018, will inform NSF about the effects of that policy on the Foundation's recruitment and retention of IPAs.

EAC-collaborative program evaluations and studies:

- Centers for Chemical Innovation (CCI). The purpose of this comprehensive assessment is to evaluate the effectiveness of the CCI program in achieving its stated goals. Key concepts of interest are CCI's influence on the nature of collaborative practices in the chemical sciences. The results of this study will be used to communicate the impact and to strengthen the design and operation of the program. Results are anticipated in FY 2019. This study is co-funded with MPS.
- EPSCoR. The purpose of this evaluation is two-fold: (1) to develop a flexible framework to explore, define, and measure research competitiveness in relation to the unique contexts of each EPSCoR jurisdiction; and (2) to collect and use evidence of jurisdictional progress toward research competitiveness over time for strategic program improvement. An understanding of how and in what ways progress is made towards increased research competitiveness will inform the use of these findings to refine existing and tailor future EPSCoR program-level activities. Results are anticipated in FY 2020. This study is co-funded with EPSCoR.
- Geoscience Education (GeoEd). This evaluation will inform strategic direction by describing the extent to which the GeoEd portfolio is contributing to and progressing toward the achievement of program goals. The purpose of this evaluation is three-fold, to: (1) develop a flexible framework to define, measure, and explore value and impact; (2) provide evidence of the range, synergies, and variability across factors contributing to impact over time; and (3) strengthen the practice of evaluative inquiry for program improvement among GeoEd decision-makers and stakeholders. Results are anticipated in FY 2018. This study is co-funded with GEO.

All ongoing projects that began in FY 2016 and FY 2017 will continue in FY 2018. In FY 2018, EAC will focus on evaluation and assessment of NSF's 10 Big Ideas. The evidence thus generated will be used to inform day-to-day operations and performance improvement as these activities mature.

In FY 2019, several of the existing evaluations described above will continue. The work on NSF's 10 Big Ideas will continue. New collaborative evaluations on other topics are not anticipated.

ESTABLISHED PROGRAM TO STIMULATE COMPETITIVE RESEARCH (EPSCOR) **$160,000,000**
-$2,800,000 / -1.7%

EPSCoR Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Total	**$162.80**	**-**	**$160.00**	**-$2.80**	**-1.7%**
Research Infrastructure Improvement (RII)	135.75	-	132.50	-3.25	-2.4%
Co-Funding	24.92	-	25.00	0.08	0.3%
Outreach and Workshops	2.13	-	2.50	0.37	17.4%

About EPSCoR

EPSCoR assists NSF in its statutory function "to strengthen research and education is science and engineering throughout the United States and to avoid undue concentration of such research and education." EPSCoR seeks to advance excellence in science and engineering research and education to achieve sustainable increases in research, education, training capacity, and competitiveness that will enable EPSCoR jurisdictions to have increased engagement in the science and engineering supported by NSF.

Based on FY 2017 funding, 14 percent of the EPSCoR portfolio was available for new research grants, and the remaining 86 percent supported research grants made in prior years.

EPSCoR uses three strategic investment tools: Research Infrastructure Improvement (RII) awards, Co-Funding, and Outreach/Workshops.

Research Infrastructure Improvement (RII)

- RII awards will continue to 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 initiatives. RII awards also invest in workforce development, increase the participation of underrepresented groups in STEM, 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: 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, including crosscutting initiatives.

Outreach and Workshops

- The Outreach and Workshops component of EPSCoR solicits requests for 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, 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.

People Involved in EPSCoR Activities

Number of People Involved in EPSCoR Activities

	FY 2017 Actual Estimate	FY 2018 (TBD)	FY 2019 Estimate
Senior Researchers	626	-	600
Other Professionals	201	-	200
Postdoctoral Associates	104	-	100
Graduate Students	493	-	500
Undergraduate Students	631	-	600
K-12 Teachers	4,236	-	4,200
K-12 Students	96,153	-	94,500
Total Number of People	**102,444**	**-**	**100,700**

UNITED STATES ARCTIC RESEARCH COMMISSION (USARC) **$1,420,000**
-$10,000 / -0.7%

USARC Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
USARC	$1.43	-	$1.42	-$0.01	-0.7%

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. In addition, USARC advises the Interagency Arctic Research Policy Committee 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.

USARC is requesting $1.42 million, $10,000 below the FY 2017 Actual level. The FY 2019 Request provides funds to advance Arctic research, and to recommend Arctic research policy that is consistent with the Administration's *FY 2019 Administrative Research and Development Budget Priorities* (M-17-30). The FY 2019 Request will support three FTE funded at USARC. In addition, the FY 2019 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) **$873,370,000**
$0 / 0%

Education and Human Resources (EHR) Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Division of Research on Learning in Formal and Informal Settings (DRL)	$222.62	-	$202.98	-$19.64	-8.8%
Division of Graduate Education (DGE)	272.11	-	258.55	-13.56	-5.0%
Division of Human Resource Development (HRD)	149.50	-	187.19	37.69	25.2%
Division of Undergraduate Education (DUE)	229.14	-	224.65	-4.49	-2.0%
Total	**$873.37**	**-**	**$873.37**	**-**	**-**

About EHR

The mission of EHR is to provide the research foundation to develop a science, technology, engineering, and mathematics (STEM)-literate public and diverse workforce that is ready to advance the frontiers of science and engineering for society. This research foundation has guided and shaped EHR's portfolio and priorities for more than 60 years. Although the EHR mission remains unchanged, the context in which the mission is enacted changes. Each decade brings new challenges and opportunities.

The progress of science and engineering depends on the education of discoverers—the future leaders and innovators in science and engineering. These discoverers will become part of the STEM and STEM-related workforce, including public and private sector, academic, policy, research, and teaching occupations. The progress of science and engineering also depends on a public that values and participates in the STEM enterprise through formal and informal education, public participation in scientific research, and civic engagement. The opportunities made possible by federal investments in STEM must be provided effectively to, and draw from, the full and diverse talent pool of the Nation.

The role of NSF, through EHR, within the federal government in supporting research on STEM education is unique. EHR programs fund crucial foundational, design and development, and implementation research that is made available to inform large investments at scale made by other agencies, organizations, and the private sector. The EHR research portfolio also supports a coherent suite of NSF-wide investments in undergraduate and graduate STEM education through strategic linkages with the discipline-specific needs of all NSF directorates and engagement in cross-directorate science and engineering initiatives. In addition, the EHR investments in preK-12 STEM education and informal STEM learning are focused, catalytic contributions that push the frontiers of effective learning and practice in those environments. Such work is foundational as a part of the national STEM education infrastructure.

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, ~~$760,550,000,~~ *$873,370,000,* to remain available until September 30, ~~2019.~~ *2020.*

Note.—A full-year 2018 appropriation for this account was not enacted at the time the budget was prepared; therefore, the budget assumes this account is operating under the Continuing Appropriations Act, 2018 (Division D of P.L. 115–56, as amended). The amounts included for 2018 reflect the annualized level provided by the continuing resolution.

Education and Human Resources
FY 2019 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 2017 Appropriation	$880.00	$5.37	-$7.66	$2.61	-$6.95	$873.37
FY 2018 Annualized CR	874.02	7.66				881.68
FY 2019 Total Request	873.37					873.37
$ Change from FY 2018 Annualized CR						-$8.31
% Change from FY 2018 Annualized CR						-0.9%

Explanation of Carryover

Within the Education and Human Resources (EHR) account, $7.66 million was carried over into FY 2018.

Excellence Awards in Science and Engineering (EASE)
- Amount: $4.21 million
- Reason: These carryover funds will be used to recognize recipients of the Presidential Awards for Excellence in Mathematics and Science Teaching and recipients of the Presidential Awards for Excellence in Science, Mathematics and Engineering Mentoring.
- Obligation: Anticipated FY 2018 Quarter 2

The remaining $3.45 million consists of funds from selected projects that were not ready for obligation in FY 2017.

Major Investments

EHR Major Investments
(Dollars in Millions)

Area of Investment	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
GRFP	$158.70	-	$135.36	-$23.34	-14.7%
NSF Research Traineeship	30.97	-	41.19	10.22	33.0%
NSF I-Corps™	1.52	-	1.55	0.03	2.0%
SaTC	54.95	-	55.00	0.05	0.1%
Understanding the Brain	11.00	-	7.00	-4.00	-36.4%
BRAIN Initiative	*2.00*	*-*	*2.00*	*-*	*-*
NSF's Big Ideas					
NSF INCLUDES	*3.58*	*-*	*20.00*	*16.42*	*458.7%*

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

Funding Profile

EHR Funding Profile

	FY 2017 Actual Estimate	FY 2018 (TBD)	FY 2019 Estimate
Statistics for Competitive Awards:			
Number of Proposals	4,293	-	4,300
Number of New Awards	898	-	900
Funding Rate	21%	-	21%
Statistics for Research Grants:			
Number of Research Grant Proposals	3,134	-	3,200
Number of Research Grants	541	-	600
Funding Rate	17%	-	19%
Median Annualized Award Size	$199,260	-	$199,800
Average Annualized Award Size	$303,529	-	$332,900
Average Award Duration, in years	3.0	-	2.9

People Involved in EHR Activities

Number of People Involved in EHR Activities

	FY 2017 Actual Estimate	FY 2018 (TBD)	FY 2019 Estimate
Senior Researchers	6,400	-	6,400
Other Professionals	2,175	-	2,200
Postdoctoral Associates	350	-	350
Graduate Students	10,800	-	10,800
Undergraduate Students	16,000	-	16,000
K-12 Teachers	36,200	-	36,200
K-12 Students	81,900	-	81,900
Total Number of People	**153,825**	**-**	**153,850**

Program Monitoring and Evaluation

EHR continues its strong emphasis on evidence-based decision making, as well as its commitment to generating robust evidence to inform the development, management, and assessment of its programs and portfolios of investment. EHR's evaluation priorities for FY 2019 include ensuring the efficient use of available administrative data assets and supporting and coordinating evidence-building and use across our STEM education and workforce programs. To accomplish this goal, EHR will extend a review of existing data assets and their use for monitoring and evaluative purposes and develop a multi-year learning agenda for assessing our STEM human capital development programs. Also, the ADVANCE program will initiate program evaluation in FY 2018, while evaluations for IUSE and the Graduate Research Internship Program (GRIP) are tentatively planned for FY 2018 or early in FY 2019.

EHR-based infrastructure and processes will continue to be developed in collaboration with the NSF Evaluation and Assessment Capability, as appropriate. EHR experts in evaluation will continue to 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.

In FY 2018, EHR will continue to collaborate with the Institute of Education Sciences (IES) to update the Common Guidelines for Education Research and Development, which was jointly released in 2013. EHR is taking the lead in the development of a companion document that will address replication and reproducibility, while IES is focused on a second document that will address data science. It is anticipated that the new publications will be released in FY 2018.

Committees of Visitors (COV):

- EHR is continuing a transition from COVs focusing on individual programs to division-wide COVs that comprehensively examine all programs in the relevant division. EHR's first division-wide COV reviewed DRL in March 2015, and the second reviewed HRD in November 2016
- In October 2016, a COV composed of nine external experts met to review four programs managed by DUE: Transforming Undergraduate Education in STEM (TUES), STEM Talent Expansion Program (STEP), Widening Implementation & Demonstration of Evidence-Based Reforms (WIDER), and Improving Undergraduate STEM Education (IUSE: EHR). (TUES, STEP, and WIDER were consolidated to form IUSE: EHR in FY 2014.) The COV chair presented a summary of the committee's recommendations, and the COV report was discussed and accepted, at the EHR Advisory Committee meeting held on November 30–December 1, 2016.
- In October 2016, another COV composed of seven external experts met to review the EHR Core Research program, which spans all four EHR divisions. The COV chair presented a summary of the committee's recommendations, and the COV report was discussed and accepted, at the EHR Advisory Committee meeting held on November 30–December 1, 2016.
- In late November 2016, a COV composed of nine external experts met to review the six programs managed by HRD—i.e., ADVANCE, Alliances for Graduate Education and the Professoriate (AGEP), Centers of Research Excellence in Science and Technology (CREST), Historically Black Colleges and Universities – Undergraduate Program (HBCU-UP), Louis Stokes Alliances for Minority Participation (LSAMP), and TCUP. The COV chair presented a summary of the COV's observations at the EHR Advisory Committee meeting held on November 30–December 1, 2016, and the COV's report was completed and then discussed and accepted at the June 2017 EHR Advisory Committee meeting.
- In fall 2018, DGE plans to hold a division-wide COV to review its programs—i.e., SFS NRT, and GRFP.
- In fall 2018, DUE also plans to hold a division-wide COV to review its programs—i.e., the Advanced Technological Education (ATE) program, IUSE: EHR, the NSF Scholarships in STEM (S-STEM) program, and the Robert Noyce Teacher Scholarship Program.

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.

DIVISION OF RESEARCH ON LEARNING IN FORMAL AND INFORMAL SETTINGS (DRL) **$202,980,000**
-$19,640,000 / -8.8%

DRL Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Total	**$222.62**	**-**	**$202.98**	**-$19.64**	**-8.8%**
Learning and Learning Environments	**25.63**	**-**	**25.63**	**-**	**-**
EHR Core Research (ECR): STEM Learning	25.63	-	25.63	-	-
Broadening Participation & Institutional Capacity	**145.11**	**-**	**144.71**	**-0.40**	**-0.3%**
Advancing Informal STEM Learning (AISL)	62.90	-	62.50	-0.40	-0.6%
Discovery Research PreK-12 (DRK-12)	82.21	-	82.21	-	-
STEM Professional Workforce	**51.88**	**-**	**32.64**	**-19.24**	**-37.1%**
Science, Technology, Engineering, Mathematics + Computing (STEM + C) Partnerships[1]	51.88	-	32.64	-19.24	-37.1%

[1]The STEM+C program will not run a new competition in FY 2019. However, it will provide co-funding to other programs supporting research on computer science education, including partnering with CISE on the Computer Science for All: Research Practitioner Partnerships (CS for ALL: RPP) program. Other EHR programs (DRK-12, AISL, and ECR: STEM Learning) will expand their portfolios to further support research addressing computer science teaching and learning, including research on computational thinking and the integration of computing with other STEM disciplines.

DRL Summary

DRL invests in foundational research to advance understanding about STEM learning and teaching. Advances in STEM learning ultimately support individuals who pursue STEM careers, as well as the Nation's STEM workforce more broadly. The DRL portfolio includes the design, implementation, and study of learning environments, models, and technologies intended to enable STEM learning for all students—particularly those who have been underrepresented in STEM—through both formal and informal STEM activities within formal education systems and beyond. DRL also provides direction for the EHR portfolio in techniques for measurement and assessment of learning outcomes.

FY 2019 priorities for DRL include:

- Invest across DRL programs in research and development at the early childhood level to foster STEM learning.
- Invest in research and development supporting computer science education, including research on computational thinking and the integration of computing with other STEM disciplines.
- Support research employing data science (associated with the Harnessing the Data Revolution Big Idea), neuroscience, and cyberlearning (associated with the Future of Work at the Human-Technology Frontier Big Idea) methodologies. This work will significantly advance the field's knowledge base on: STEM learning and learning environments; broadening participation and institutional capacity in STEM; and increasing retention for students traditionally underserved in STEM at the preK-12, undergraduate, and/or graduate level.
- Provide a focus on research and development on STEM learning cutting across formal and informal settings.
- Fund research and development related to understanding, measuring, and enhancing socioemotional skills, such as persistence, teamwork, and learning to learn, in the context of STEM education.

DIVISION OF GRADUATE EDUCATION (DGE) **$258,550,000**
-$13,560,000 / -5.0%

DGE Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Total	**$272.11**	**-**	**$258.55**	**-$13.56**	**-5.0%**
Learning and Learning Environments	**11.51**	**-**	**11.03**	**-0.48**	**-4.2%**
Project and Program Evaluation (PPE)	11.51	-	11.03	-0.48	-4.2%
STEM Professional Workforce	**260.60**	**-**	**247.52**	**-13.08**	**-5.0%**
CyberCorps®: Scholarship for Service (SFS)	54.95	-	55.00	0.05	0.1%
EHR Core Research (ECR): STEM Professional Workforce Preparation	15.98	-	15.97	-0.01	-0.1%
Graduate Research Fellowship (GRFP)	158.70	-	135.36	-23.34	-14.7%
NSF Research Traineeship (NRT)	30.97	-	41.19	10.22	33.0%

DGE Summary

DGE provides leadership across NSF for investments that support U.S. graduate students in STEM, and for improvement and innovation in graduate education to prepare tomorrow's STEM leaders. DGE focuses on the development of the broad STEM professional workforce through graduate education.

FY 2019 priorities for DGE include:

- Maintain DGE's SFS collaborations with other federal agencies to explore mechanisms through which members of this cybersecurity workforce can continue to contribute to the government throughout their careers. In addition, DGE will continue activities in the SFS program that strengthen and expand the capacity of universities to develop a diverse cadre of cybersecurity experts for the Nation.
- Continue the goal of GRFP to help build the U.S. STEM human capital necessary to ensure the Nation's leadership in advancing innovations in science and engineering.
- Invest in NRT, including the IGE track.

In collaboration with BIO, DGE has administrative and intellectual responsibility for the implementation of the *NSF Strategic Framework for Investments in Graduate Education: FY 2016-FY 2020*.[1] DGE also leads the EHR evaluation portfolio (particularly in the area of human capital).

[8]www.nsf.gov/pubs/2016/nsf16074/nsf16074.pdf

DIVISION OF HUMAN RESOURCE DEVELOPMENT (HRD) **$187,190,000**
+$37,690,000 / 25.2%

HRD Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Total	**$149.50**	**-**	**$187.19**	**$37.69**	**25.2%**
Learning and Learning Environments	**58.56**	**-**	**75.00**	**16.44**	**28.1%**
ADVANCE	1.53	-	18.00	16.47	1074.2%
Alliances for Graduate Education and the Professoriate (AGEP)	8.01	-	8.00	-0.01	-0.1%
Historically Black Colleges and Universities Undergraduate Program (HBCU-UP)	35.01	-	35.00	-0.01	-0.0%
Tribal Colleges and Universities Program (TCUP)	14.01	-	14.00	-0.01	-0.1%
Broadening Participation & Institutional Capacity	**62.61**	**-**	**83.88**	**21.27**	**34.0%**
EHR Core Research (ECR): Broadening Participation and Institutional Capacity in STEM	12.88	-	12.88	-	-
IUSE: Hispanic Serving Institutions (HSI) Program[1]	-	-	5.00	5.00	N/A
Big Idea: NSF INCLUDES	3.58	-	20.00	16.42	457.9%
Louis Stokes Alliances for Minority Participation (LSAMP)	46.15	-	46.00	-0.15	-0.3%
STEM Professional Workforce	**28.33**	**-**	**28.31**	**-0.02**	**-0.1%**
Centers for Research Excellence in Science and Technology (CREST)	24.02	-	24.00	-0.02	-0.1%
Excellence Awards in Science and Engineering (EASE)	4.31	-	4.31	-	-

[1]In FY 2017, the IUSE: HSI Program was funded at $15.0 million within the Integrative Activities budget. These funds were carried over into FY 2018, and will be used for awards made in FY 2018. EHR is responsible for the management of this program.

HRD Summary

HRD provides support to grow the innovative and competitive U.S. STEM workforce by supporting the inclusion and success of individuals currently underrepresented in STEM and the institutions that serve them, and conducting research on effective mechanisms and models for achieving these objectives.

FY 2019 priorities for HRD include:

- Continue HRD's role in NSF-wide activities to strengthen inclusion and broadening participating for all groups in STEM.
- Collaborate with all NSF directorates to encourage HBCU faculty to submit proposals to other directorates and enhance research capability at HBCUs.
- Encourage institutional collaboration with other federal agencies, state governments, national laboratories, private sector research labs, and K-12 schools, districts and state agencies to advance knowledge and education on research of significance to the Nation.
- Support programs with objectives to broaden participation and increase institutional capacity in STEM by increasing retention of students traditionally underserved in STEM.
- Support professional development for K-12 teachers and STEM educators and mentors, as well as the identification and recognition of outstanding educators in partnership with the Office of Science and Technology Policy.

DIVISION OF UNDERGRADUATE EDUCATION (DUE) **$224,650,000**
-$4,490,000 / -2.0%

DUE Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 Request	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Total	**$229.14**	**-**	**$224.65**	**-$4.49**	**-2.0%**
Learning and Learning Environments	**100.12**	**-**	**110.10**	**9.98**	**10.0%**
EHR Core Research (ECR): STEM Learning Environments	13.11	-	13.10	-0.01	-0.1%
IUSE: Hispanic Serving Institutions (HSI) Program[1]	-	-	10.00	10.00	N/A
Improving Undergraduate STEM Education (IUSE)	87.01	-	87.00	-0.01	-0.0%
STEM Professional Workforce	**129.02**	**-**	**114.55**	**-14.47**	**-11.2%**
Advanced Technological Education (ATE)	65.91	-	66.00	0.09	0.1%
NSF Innovation Corps (I-Corps™)	1.52	-	1.55	0.03	2.0%
Robert Noyce Teacher Scholarship Program (Noyce)	61.59	-	47.00	-14.59	-23.7%

[1]In FY 2017, the IUSE: HSI Program was funded at $15.0 million within the Integrative Activities budget. These funds were carried over into FY 2018, and will be used for awards made in FY 2018. EHR is responsible for the management of this program.

DUE Summary

DUE supports excellence in undergraduate STEM education for all students. To accomplish this mission, DUE funds projects that design, develop, and implement high-quality educational experiences, as well as the scientific research needed to evaluate the effectiveness of those experiences. The resulting STEM learning environments integrate cutting-edge science and education research results to improve learning for all undergraduates. DUE investments promote improved teaching practices across the full range of U.S. higher education: community colleges, four-year colleges, comprehensive public institutions, and research universities, including flagship, state-supported systems. In turn, improved STEM education opens multiple career pathways for undergraduates. For example, innovative educational programs at community colleges enable students to gain expertise in advanced technologies such as additive manufacturing, biotechnology, precision agriculture, nano-optics, or cybersecurity; this expertise can lead directly to employment in those sectors. At baccalaureate degree-granting institutions, STEM majors can pursue alternative teaching certification to enter the K-12 teaching workforce in high-need school districts. Overall, improvements in STEM education enhance student learning, which supports greater retention and degree attainment, broadening the pool of future STEM researchers, and helping meet workforce needs for STEM-knowledgeable individuals.

FY 2019 priorities for DUE include:

- Support and influence the nationwide movement to improve undergraduate STEM education through the creation and study of innovative learning environments for undergraduate STEM disciplinary and interdisciplinary learning. DUE also continues to be the main source of support across federal agencies for discipline-based educational research (DBER).[2] DBER translates disciplinary expertise and evidence from the learning sciences into physical and virtual tools, technologies, and other learning experiences. It then uses research and development strategies to iteratively improve these products. Through these design-research cycles, DBER has the potential to improve STEM learning at scale.

[2]Singer, Nielsen, and Schweingruber. "Discipline-based education research." *Washington, DC: The National Academies* (2012). Retrieved from: www.nap.edu/catalog/13362/discipline-based-education-research-understanding-and-improving-learning-in-undergraduate

- Focus on investments for improving mathematics learning and teaching, particularly in the first two years of college; improving data science learning; developing students' skills, work habits, and character as they gain STEM knowledge; and developing the next generation of researchers who will study STEM and undergraduate STEM education. In FY 2019, emphasis will be placed on increasing access to early research experiences and on institution-wide improvement in STEM education.
- Increase the population of diverse, innovative STEM and STEM-knowledgeable workers. To this end, DUE will also focus on improving the preparation of future K-12 teachers and highly skilled technicians in advanced technology industries. In FY 2019, special attention will be placed on attracting proposals to IUSE: EHR led by investigators from minority-serving community colleges, as well as investigators from two- and four- year institutions with prior funding from HBCU-UP and TCUP. All DUE programs will emphasize research and development on increasing the success of low income and other underrepresented undergraduate groups in making the transition from two-year to four-year STEM degree programs.

H-B NONIMMIGRANT PETITIONER FEES **$100,000,000**

In FY 2019, H-1B Nonimmigrant Petitioner Fees are projected to be $100.0 million.

H-1B Nonimmigrant Petitioner Fees Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 Estimate	FY 2019 Request	FY 2019 Request Change Over FY 2018 Estimate Amount	FY 2019 Request Change Over FY 2018 Estimate Percent
H-1B Nonimmigrant Petitioner Fees Funding	$119.48	$142.00	$100.00	-$42.00	-29.6%

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).

Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM).

The S-STEM program began in 1999 under P.L. 105-277. Originally, the program was named Computer Science, Engineering, and Mathematics Scholarships (CSEMS) and supported grants for scholarships to academically-talented students with demonstrated financial need 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." As a result, the program was renamed in 2006 from CSEMS to S-STEM.

- 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 more than 6,500 proposals from all types of colleges and universities and has made 1,923 awards. In addition to scholarships, S-STEM awards also provide funding for student support activities featuring close involvement of faculty, student mentoring, academic support, curriculum development, and recognition of student accomplishments. Such activities are important in recruiting and retaining students in high-technology fields through graduation and into employment. In FY 2019, in addition to the long-standing scholarship support, all S-STEM projects will contribute to conduct research on interventions that affect associate or baccalaureate STEM degree attainment by 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, this research is important to understand this success so that effective practices can be used at scale. Approximately 90 awards are anticipated in FY 2019, with a continued emphasis on increasing involvement of community colleges, especially Hispanic-serving institutions. S-STEM activities in FY 2019 will leverage efforts in IUSE: EHR, LSAMP, and the HSI Program to enhance persistence of students. S-STEM will continue to be a partner in the NSF INCLUDES initiative. S-STEM programming and research also will align with NRT, with the goal of understanding and enhancing effective learning environments and pathways for students on the continuum from two-year to four-year to master's and doctoral degrees.

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 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).

- Private-Public Partnerships in K-12: ITEST. The ITEST program invests in K-12 activities that address the ongoing and growing need for STEM professionals and information technology workers in the U.S. and seeks solutions to help ensure the breadth and depth of the U.S. 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 3,507 grant proposals and made 457 awards (including co-funded projects) that allow K-12 students and teachers to work closely with scientists, engineers, and other STEM professionals on extended research projects that promote awareness of STEM careers and interest in pursuing education pathways to those careers. Funded 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 historically underrepresented in those careers. In FY 2019, ITEST will be a partner in the NSF INCLUDES initiative and will make approximately 25-30 awards.

H-1B Financial Activities from FY 2008 - FY 2017

(Dollars in Millions)

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
Receipts	**$104.43**	**$88.66**	**$91.22**	**$106.11**	**$128.99**	**$120.94**	**$132.49**	**$143.00**	**$138.80**	**$141.07**
Unobligated Balance start of year	**$63.37**	**$50.83**	**$52.62**	**$50.15**	**$60.93**	**$99.31**	**$108.31**	**$111.39**	**$116.02**	**$74.63**
Appropriation Previously unavailable (Sequestered)							**$5.10**	**$9.54**	**$7.30**	**$6.80**
Appropriation Currently unavailable (Sequestered)							**-$9.54**	**-$7.30**	**-$6.80**	**-$9.73**
Obligations incurred:										
Scholarships in Science, Technology, Engineering, and Mathematics	92.40	61.22	75.96	77.67	72.57	83.98	92.18	109.34	140.54	84.38
Private-Public Partnership in K-12[1]	28.72	27.86	20.85	18.62	21.59	31.51	37.23	29.83	44.35	35.11
Total Obligations	**$121.12**	**$89.08**	**$96.81**	**$96.29**	**$94.16**	**$115.49**	**$129.41**	**$139.17**	**$184.89**	**$119.49**
Unallocated Recoveries			2.20	3.12	0.96	3.55	-	4.95	1.60	3.58
Unobligated Balance end of year	**$46.68**	**$50.41**	**$49.24**	**$63.09**	**$96.72**	**$108.31**	**$111.39**	**$122.41**	**$72.03**	**$96.86**

[1]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.

Explanation of Carryover

Within the H-1B no-year account, $96.86 million was carried over into FY 2018.

Innovation Technology Experiences for Students (ITEST)

- Amount: $21.84 million
- Reason: 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.
- Anticipated Obligation: FY 2018 Quarter 4

Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM)

- Amount: $75.02 million
- Reason: 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.
- Anticipated Obligation: FY 2018 Quarter 4

MAJOR RESEARCH EQUIPMENT AND FACILITIES CONSTRUCTION (MREFC)

$94,650,000
-$128,130,000 / -57.5%

Major Research Equipment and Facilities Construction Funding

(Dollars in Millions)

	FY 2017 Actual	FY 2018 Request	FY 2019 Request	Change Over FY 2017 Actual Amount	Change Over FY 2017 Actual Percent
Major Research Equipment and Facilities Construction	$222.78	$182.80	$94.65	-$128.13	-57.5%

The MREFC account supports the acquisition, construction, and commissioning of major research infrastructure that provides unique capabilities at the frontiers of science and engineering. Initial planning, design, and post-construction operations and maintenance are funded through the R&RA account.

MREFC Account Funding, by Project

(Dollars in Millions)

	FY 2017 Actual	FY 2018 Request	FY 2019 Request	FY 2020 Estimate	FY 2021 Estimate	FY 2022 Estimate	FY 2023 Estimate	FY 2024 Estimate
DKIST	$18.30	$20.00	$16.13	-	-	-	-	-
LSST	60.18	57.80	48.82	46.34	40.75	5.36	-	-
NEON	22.10	-	-	-	-	-	-	-
RCRV	121.88	105.00	28.70	-	-	-	-	-
Enhanced Oversight	0.33	-	1.00	1.00	1.00	1.00	1.00	1.00
Total	**$222.78**	**$182.80**	**$94.65**	**$47.34**	**$41.75**	**$6.36**	**$1.00**	**$1.00**

Modern and effective research infrastructure is critical to maintaining U.S. international leadership in science and engineering. 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 or cyber-infrastructure 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 review and approval.

In FY 2019, NSF requests $94.65 million to continue construction of three ongoing projects: Daniel K. Inouye Solar Telescope (DKIST), Large Synoptic Survey Telescope (LSST), and Regional Class Research Research Vessels (RCRV). For more information on each project, including the disposition of construction support for the National Ecological Observatory Network (NEON), see the individual narratives later in this chapter.

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 infrastructure such that approved budgets are sufficient to accomplish the scientific objectives. The current policy as published in NSF's Large Facilities Manual (LFM) requires that: (1) the total project cost estimate when exiting the preliminary design phase includes adequate contingency to cover foreseeable risks; (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; and (3) if the project is approved to continue

and further scope reductions become too detrimental to science, then the first 10 percent of any cost increase must be covered by the sponsoring directorate through R&RA funding. This final step was required for NEON, as described in the individual narrative for the project.

All projects funded through the MREFC account undergo periodic cost, schedule, and risk reviews as required by the LFM and the terms and conditions of the cooperative agreements. NSF policies and reporting requirements are designed to ensure routine and reliable tracking of progress (including the use of Earned Value Management), project spending, and use of contingency, and that program and recipients each have sufficient oversight and management authority (respectively) to meet project objectives.

Enhanced NSF Oversight

NSF has greatly strengthened its oversight of major facility projects in recent years, with a number of those enhancements now codified in the American Innovation and Competitiveness Act (AICA) of 2017. One significant enhancement is holding a portion of budget contingency (up to 100 percent) and only allocating to the program for obligation to the project based on demonstrated need. This oversight mechanism will generally result in some MREFC carryover each year; however, future obligation is anticipated to manage project risks.

Enhanced oversight of the construction stage now also includes mandatory incurred cost audits and independent cost estimates, as well as other audits and reviews based on NSF's annual major facility portfolio risk assessment. These efforts are conducted by NSF and are generally not attributable to a specific project at the time of budget formulation, nor are they part of the total project cost developed and managed by the recipient. To properly support and transparently account for these efforts, actual costs and future estimates for Enhanced Oversight are shown separately from projects in the MREFC account table. In FY 2017 and FY 2018, these activities are supported with funds recovered from projects completed in previous years.

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, ~~$182,800,000~~*$94,650,000* to remain available until expended.

Note.—A full-year 2018 appropriation for this account was not enacted at the time the budget was prepared; therefore, the budget assumes this account is operating under the Continuing Appropriations Act, 2018 (Division D of P.L. 115–56, as amended). The amounts included for 2018 reflect the annualized level provided by the continuing resolution.

Major Research Equipment and Facilities Construction
FY 2019 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 2017 Appropriation	$209.00	$37.21	-$31.36	$2.07	$5.86	$222.78
FY 2018 Annualized CR	207.58	31.36				238.94
FY 2019 Request	94.65					94.65
$ Change from FY 2018 Annualized CR						-$144.29
% Change from FY 2018 Annualized CR						-60.4%

Explanation of Carryover

Within the Major Research Equipment and Facilities Construction account, $31.36 million was carried over into FY 2018.

National Ecological Observatory Network (NEON)
- Amount: $11.06 million
- Reason: Ongoing construction and budget contingency funding needed for project completion scheduled for FY 2018. For additional information, please see the NEON section of the MREFC Chapter.
- Obligation: Anticipated FY 2018 Quarter 4

- Amount: $3.15 million
- Reason: Program funds reserved for unknown or unforeseen risks as identified by NSF.
- Obligation: TBD - Funds held in reserve unless required.

Large Synoptic Survey Telescope
- Amount: $13.64 million
- Reason: Budget contingency funding not obligated in FY 2017.
- Obligation: Anticipated FY 2018 Quarter 4

Daniel K. Inouye Solar Telescope
- Amount: $1.70 million
- Reason: Budget contingency funding not obligated in FY 2017.
- Obligation: Anticipated FY 2018 Quarter 4

The remaining $1.81 million is from completed projects and ended tasks, most recently the Ocean Observatories Initiative and Large Hadron Collider. In FY 2018 NSF intends to use a portion of it for enhanced oversight of MREFC projects. For a further description of the enhanced oversight activities, see the MREFC chapter.

The MREFC Account for FY 2019

The following narratives present detailed information on NSF's MREFC-funded construction projects with the sponsoring organization noted in parenthesis.

DANIEL K. INOUYE SOLAR TELESCOPE (DKIST) $16,130,000

The FY 2019 Budget Request for NSF's Daniel K. Inouye Solar Telescope is $16.13 million. This represents the final year in an 11-year funding profile within a National Science Board approved not-to-exceed total project cost of $344.13 million. Completion of construction atop Haleakalā on Maui, Hawai'i is planned for no later than June 2020.

When completed, DKIST will be the world's most powerful solar observatory, poised to answer fundamental questions in solar physics by providing transformative improvements over current ground-based facilities. DKIST will enable the study of magnetic 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. Solar activity can affect civil life on Earth through phenomena generally described as space weather, and may impact 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] DKIST will play an important role in enhancing the "fundamental understanding of space weather and its drivers," an objective called out in the National Space Weather Strategy and associated *National Space Weather Action Plan*[3] both of which were released by the National Science and Technology Council on October 29, 2015.

Appropriated and Requested MREFC Funds for the Daniel K. Inouye Solar Telescope

(Dollars in Millions)

	Prior Years	FY 2014 Actual	FY 2015 Actual	FY 2016 Actual	FY 2017 Actual	FY 2018 Request	FY 2019 Request	Total Project Cost
MREFC Approp.	$60.00	$36.88	$25.12	$20.00	$20.00	$20.00	$16.13	$198.13
ARRA MREFC Appropriation	146.00	-	-	-	-	-	-	146.00
Total	**$206.00**	**$36.88**	**$25.12**	**$20.00**	**$20.00**	**$20.00**	**$16.13**	**$344.13**

Baseline History

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 through the Division of Atmospheric and Geospace Sciences (AGS) in the Directorate for Geosciences (GEO). The current design, cost, schedule, and risk were scrutinized in an NSF-conducted Preliminary Design Review in October-November 2006.

The original total project cost to NSF, $297.93 million, was set after a Final Design Review (FDR) in May 2009, which determined that the project was fully prepared to begin construction. The National Science Board (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. In FY 2009, $153.0 million was appropriated to initiate construction. Funding was provided through a combination of the MREFC account ($7.0 million) and the American Recovery and Reinvestment Act (ARRA) account ($146.0 million). Given the timing of the receipt of budget authority and the complexity of project

[1] www.nap.edu/catalog.php?record_id=12951
[2] www.nap.edu/search/?term=13060&x=0&y=0
[3] www.hsdl.org/?view&did=789864

contracting, the entire $153.0 million was carried over from FY 2009 and obligated in FY 2010. The environmental compliance requirements were completed on November 20, 2009, and the NSF Director signed the Record of Decision authorizing construction on December 3, 2009. The Hawai'i Board on Land and Natural Resources (BLNR) approved the project's application for a Conservation District Use Permit (CDUP) on December 1, 2010. The Hawai'i BLNR approved a Habitat Conservation Plan, designed to protect and rehabilitate habitats of the endangered Hawai'ian petrel and Hawai'ian goose that could potentially be affected by the construction of DKIST. The U.S. Fish and Wildlife Service completed a formal consultation regarding the endangered Hawai'ian petrel in 2011. A contested case challenge to the 2010 CDUP issuance delayed site construction until the BLNR ruled in favor of the DKIST project and issued a new CDUP November 2012. Full access to the site atop Haleakalā followed shortly thereafter. Site preparation and excavation began November 30, 2012.

The DKIST telescope enclosure and Support and Operations building at the site on Haleakala, Maui, HI. *Credit: Dave Boboltz, NSF.*

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 2012. An external panel of experts reviewed the revised baseline and increased the total project cost by approximately $46.20 million. The NSB also subsequently considered and approved a revised total project cost of $344.13 million at their August 2013 meeting.

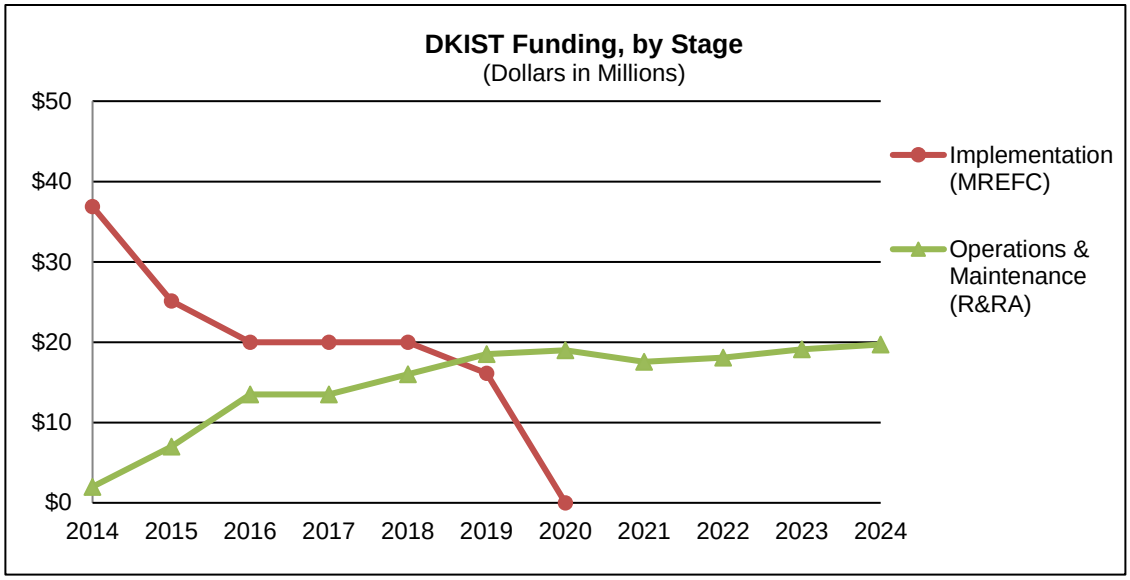
Total Funding Requirements for DKIST

(Dollars in Millions)

	Prior Years[1]	FY 2017 Actual	FY 2018 Request	FY 2019 Request	ESTIMATES FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
R&RA:									
Concept & Development	$20.41	-	-	-	-	-	-	-	-
Operations & Maintenance[2]	13.50	13.50	16.00	18.50	19.01	17.54	18.08	19.13	19.71
ARRA	3.10	-	-	-	-	-	-	-	-
Subtotal, R&RA	$37.01	$13.50	$16.00	$18.50	$19.01	$17.54	$18.08	$19.13	$19.71
MREFC:									
Implementation	142.00	20.00	20.00	16.13	-	-	-	-	-
ARRA	146.00	-	-	-	-	-	-	-	-
Subtotal, MREFC	$288.00	$20.00	$20.00	$16.13	-	-	-	-	-
TOTAL REQUIREMENTS	**$325.01**	**$33.50**	**$36.00**	**$34.63**	**$19.01**	**$17.54**	**$18.08**	**$19.13**	**$19.71**

[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 million 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 partners include the Air Force Office of Scientific Research and international groups in Germany, the United Kingdom, and Italy. Some partnership activities include:

- The U.S. Air Force replaced the aluminizing chamber at their Advanced Electro-Optical System telescope on Maui and sized it to accommodate the DKIST primary mirror. An Interagency Agreement for use of the Mirror Coating Facility (MCF) was signed by NSF and the U.S. Air Force in FY 2017. This eliminates the need to build a dedicated aluminizing chamber for DKIST.
- Kiepenheuer-Institut für Sonnenphysik (KIS; Freiburg, Germany) is constructing a narrow-band first-light instrument named the Visible Tunable Filter (VTF) as an in-kind contribution.
- Queens University Belfast (Northern Ireland) is leading a consortium of institutions from the United Kingdom that will supply high-speed visible cameras to feed the DKIST instruments.

Discussions of other possible contributions for second-generation instruments, algorithm development, coordinated observations, and student exchange are ongoing.

Management and Oversight

- NSF Structure: NSF oversight is handled by a program officer in AST working cooperatively with staff from MPS, the Office of Budget, Finance, and Award Management (BFA), the Office of the General Counsel, and the Office of Legislative and Public Affairs. Within BFA the Large Facilities Office (LFO) provides advice to program staff and assists with agency oversight and assurance. Representatives from the above NSF offices comprise the DKIST Integrated Project Team (IPT), which meets on a quarterly basis to discuss outstanding project issues.
- External Structure: NSO conducts the construction project. 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 managing organization, the Association of Universities for Research in Astronomy, Inc. (AURA). The DKIST CSA for construction runs through the end of FY 2019, and will be extended to cover the FY 2020 completion date. In 2015, the NSO CA and O&M CSA were renewed through the end of FY 2024. 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 DKIST. The project manager has experience in large telescope development, having served as lead telescope

engineer for the Gemini Telescopes project. Several councils and working groups give input from the solar and space physics communities.

Reviews

- 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.
- Earned Value Management (EVM) System Review: LFO and AST conducted a review of the DKIST project's EVM system, September 20-22, 2016. The external reviewers verified the project's EVM system and conducted interviews with project management and individual cost account managers to validate the input estimates/data into the system. The evaluation team found that the EVM System has been effectively implemented and is being used to provide reliable project management information. The NSF formally accepted the project's EVM System in a notification dated February 22, 2017.
- Software Quality Assurance (SQA) Assessment: LFO engaged a contractor to perform an assessment of the DKIST project's processes and procedures for producing the software systems to be delivered at DKIST first light. The SQA assessment consisted of a document desk review followed by videoconference conducted July 10, 2017. The final report was received by NSF on October 3, 2017. The Executive Summary from the report states: "The results of the SQA assessment found that the processes and procedures employed by the project are reasonable to produce quality software." The report findings and recommendations have been relayed to AURA, NSO and the DKIST Project.
- Independent Risk Assessment (IRA): LFO engaged a contractor to perform an independent assessment of the project's remaining risks as DKIST enters the critical integration, testing and commissioning (IT&C) stage of construction. The IRA consisted of a document desk review followed by an in-person meeting on September 21, 2017. The final report was received by NSF on December 11, 2017. The final report transmittal memo from the contractor states: "We are pleased to report that the DKIST project has a mature risk management program that is well-positioned entering the Integration, Testing, and Commissioning (IT&C) phase. We found no critical areas that require corrective action."
- Programmatic Review: A comprehensive programmatic review of the DKIST MREFC construction project took place September 19-21, 2017 in Boulder, CO. This external programmatic review focused on the IT&C phase of construction. The final report was received by NSF on October 27, 2017. The Executive Summary from the report states: "The Panel found that the project is performing exceptionally well", and that "the Project is on track to complete the project within the project deadline and budget, and that the Project's science goals are attainable."

Project Status

The DKIST project continues to make progress on construction at the summit of Haleakalā on Maui, HI, while remaining in compliance with all local, state, and federal environmental and cultural requirements. The project continues to consult with various stakeholders on a regular basis including the Hawai‘i Department of Land and Natural Resources, the Hawai‘i Department of Fish and Wildlife, the U.S. Fish and Wildlife Service, the Federal Aviation Administration, the National Park Service, and Native Hawai‘ian cultural practitioners.

<u>Construction highlights</u>:

- The project continues to work on interior fit and finish items for the enclosure (dome) and the support and operations building.
- Work continues on the critical facility thermal systems.
- In FY 2017 the primary mirror (M1) and the M1 cell assembly were transported to Maui from Arizona and Belgium, respectively. The M1 and the M1 cell assembly were successfully transported to the summit of Haleakalā. In FY 2018 the M1 will be coated at the MCF and installed in the telescope support structure.
- The Coudé rotator platform assembly inside the enclosure is completed. Site acceptance testing was

completed and the project is resolving punch-list items.
- Assembly of the Telescope Mount will be completed in FY 2018.
- Fabrication of the DKIST first-light instruments is continuing through FY 2018.

In FY 2019 the installation of the telescope structure and mechanical controls will be completed. By the end of FY 2019 the integration, testing, and commissioning of the M1 and the facility class instruments will be well underway.

Cost and Schedule
The original baseline not-to-exceed, risk-adjusted cost was established following FDR. As noted above, a revised project baseline review was held in October 2012; NSB 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). A Monte Carlo analysis of the risk-adjusted project end date at the time of the project re-baseline indicated June 10, 2020 at an 80 percent Confidence Level for successful completion. The project is currently on track for a FY 2020 end date.

Risks
Project management control, interface control, and change controls are in place. The project also maintains a risk register that is reviewed and updated on a monthly basis.

Technical: The majority of the remaining technical risk is very low as a result of the long design and development phase, with the exception of one first-light instrument: the VTF mentioned above. The cooperative support agreement between NSF and AURA identifies four facility-class instruments (not including the VTF) to be delivered by the DKIST project at the end of the MREFC construction phase. The project is on track to deliver those four instruments. The VTF is a fifth instrument and is an in-kind contribution from the German Kiepenheuer-Institut für Sonnenphysik (KIS) being designed and developed through a Memorandum of Understanding (MOU) between AURA and KIS; therefore, the fabrication risks for this instrument remain with the German institute. KIS is currently on track to deliver a single-etalon version of the instrument to DKIST. The DKIST project and AURA continue to work with KIS to ensure that the instrument is delivered on schedule and on budget.

The Telescope Mount as of July 2017, showing two recently-completed Nasmyth platforms left and right of the main structure. *Credit: P. Jeffers NSO/DKIST.*

Environmental and Cultural Compliance: AST, NSF's Office of the General Counsel, and the DKIST project have carefully worked through the applicable statutes, and a cultural monitor has been retained during construction. All required permits are in place and semi-annual consultations with a Native Hawai'ian working group continue. The two outstanding legal appeals with the potential to impact project construction were resolved in favor of the DKIST project. On October 6, 2016, the Hawai'i Supreme Court ruled against the appellant in the two cases and upheld both the DKIST project's conservation district use permit (CDUP) and the University of Hawai'i Haleakalā Observatory Management Plan. These decisions substantially reduced the risks to DKIST construction due to permitting issues.

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.

Operations Costs

DKIST operations are funded through R&RA. In FY 2019, the budget request of $18.50 million includes $16.50 million for DKIST operations and $2.0 million for cultural mitigation activities as agreed to during the compliance process.

LARGE SYNOPTIC SURVEY TELESCOPE (LSST) $48,820,000

The FY 2019 Budget Request for the Large Synoptic Survey Telescope is $48.82 million. This is the sixth year of support for a nine-year project that began in August 2014. The National Science Board approved not-to-exceed total project cost is $473.0 million for NSF's contribution to the project's scope.

Appropriated and Requested MREFC Funds for the Large Synoptic Survey Telescope
(Dollars in Millions)

FY 2014 Actual	FY 2015 Actual	FY 2016 Actual	FY 2017 Actual	FY 2018 Request	FY 2019 Request	FY 2020 Estimate	FY 2021 Estimate	FY 2022 Estimate	Total Project Cost
$27.50	$79.64	$99.67	$67.12	$57.80	$48.82	$46.34	$40.75	$5.36	$473.00

LSST is located in Chile and, when completed, 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 set by considering four key science areas:

- the physics of dark energy and dark matter
- a census of small bodies in the solar system, including potentially hazardous Near Earth Objects
- the structure and contents of the Milky Way galaxy
- 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 will result in a comprehensive data set that will enable hundreds of fundamental astrophysical studies by the entire research community on these and other topics. Thus, LSST has the potential to advance every field of astronomical study, from the inner Solar System to the large-scale structure of the Universe.

Baseline History
LSST is a joint NSF/Department of Energy (DOE) project to build an instrument that was ranked the top large ground-based astronomy project by the National Research Council 2010 Decadal Survey.[4]

Prior to NSF's construction award, NSF, DOE, and private (non-federal) partners invested over $130.0 million in LSST-related work. About 70 percent supported design and development and about 30 percent, from the non-federal funding, supported casting and polishing of the innovative combined primary-tertiary mirror (M1M3), initial site preparation, and prototype detector creation and evaluation, all of which significantly reduced construction risk.

NSF and DOE conducted a series of reviews in 2011 and 2012 to determine the project baseline, including the NSF Preliminary Design Review (PDR) and a subsequent cost estimation review. Plans were kept up-to-date to synchronize the DOE and NSF funding profiles as reviews continued, leading to NSF's Final Design Review (FDR) in December 2013. NSF then carried out a detailed cost analysis prior to following through on its approval process and making an award in the last quarter of FY 2014.

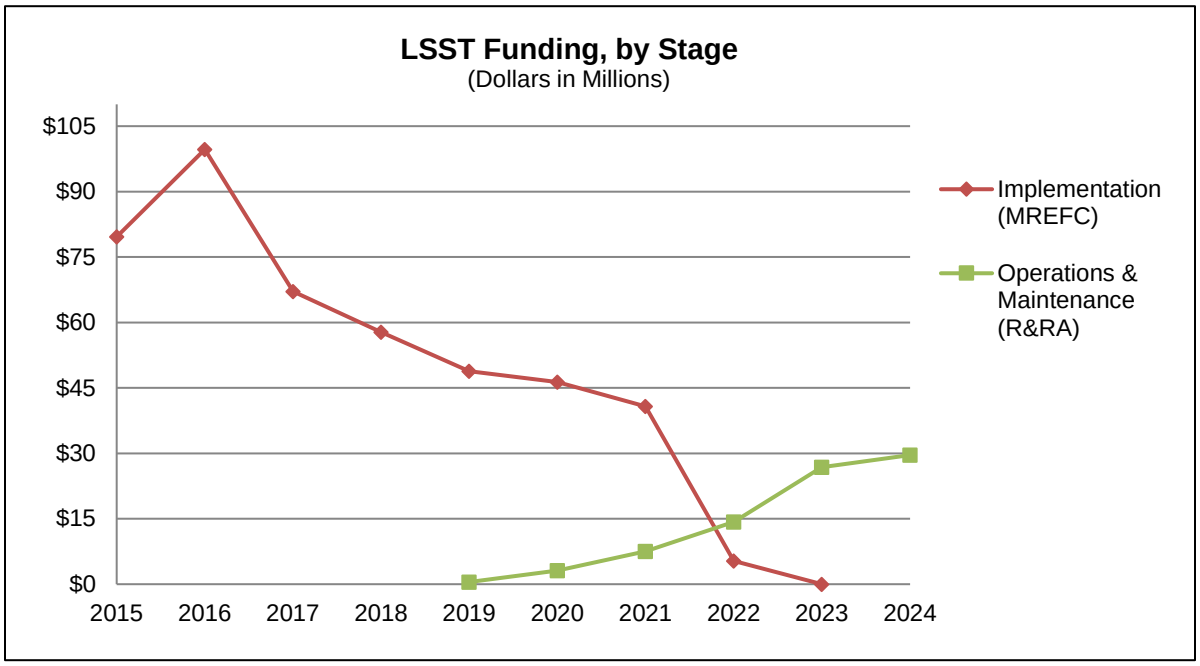
[4] http://sites.nationalacademies.org/bpa/BPA_049810

Total Funding Requirements for LSST

(Dollars in Millions)

	Prior Years[1]	FY 2017 Actual	FY 2018 Request	FY 2019 Request	ESTIMATES FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
R&RA:									
Concept & Development	$57.13	-	-	-	-	-	-	-	-
Operations & Maintenance	-	-	-	0.50	3.10	7.50	14.30	26.80	29.60
Subtotal, R&RA	$57.13	-	-	$0.50	$3.10	$7.50	$14.30	$26.80	$29.60
MREFC:									
Implementation	206.81	67.12	57.80	48.82	46.34	40.75	5.36	-	-
Subtotal, MREFC	$206.81	$67.12	$57.80	$48.82	$46.34	$40.75	$5.36	-	-
TOTAL REQUIREMENTS	**$263.94**	**$67.12**	**$57.80**	**$49.32**	**$49.44**	**$48.25**	**$19.66**	**$26.80**	**$29.60**

[1] Concept & Development funding and Implementation funding are cumulative of all prior years; Operations & Maintenance funding reflects prior year actual obligations only.



LSST Science Plan

The site at Cerro Pachón, Chile was selected for LSST because of the excellent sky transparency and image quality (known as 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 changing and transient objects within 60 seconds of their discovery. Repeated deep imaging of every part of the accessible sky will turn up explosive events such as cataclysmic variable stars, supernovae, and the optical counterparts of X-ray flashes, as well as finding moving objects and better characterizing those already known. Estimates of LSST's ability to locate Near Earth Objects (NEOs) and Potentially Hazardous Asteroids (PHAs) have been refined by LSST Project members, as well as by external studies, including an independent Jet Propulsion Laboratory study supported by NASA's Planetary Defense Coordination Office. Assuming other existing NEO efforts continue, at the end of LSST's 10-year prime mission, the catalog for objects larger than about 140 meters across should be about 75 percent complete for NEOs (about 80 percent

for PHAs), approximately 15 percent more complete than without LSST.

LSST data will be widely accessible, and discovery opportunities will be available to K-12 students as easily as to professional astronomers. 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 is planned to be located at the National Center for Supercomputing Applications in Illinois.

Management and Oversight

- NSF Structure: NSF oversight is handled by a program officer in the MPS Division of Astronomical Sciences (AST) working cooperatively with NSF staff from MPS, BFA, OGC, OLPA, and OISE. 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 weekly meetings of a joint oversight group and was formalized through a Memorandum of Understanding signed in July 2012.
- External Structure: The responsible awardee for LSST construction is the Association of Universities for Research in Astronomy, Inc. (AURA), a non-profit science management corporation consisting of 44 U.S. institutional members and four international affiliates. AURA works closely with the LSST Corporation (LSSTC), which initiated LSST development and remains responsible for privately raised funding. AURA and LSSTC established the LSST Project Office as an AURA-managed center for construction; this 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 approval of NSF and DOE.

Reviews

- Technical Reviews: Reviews were conducted throughout the design and development phase, culminating in NSF's FDR in December 2013, with DOE involvement. 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 also scrutinized by the technical reviews. During construction, NSF and DOE are holding regular joint progress reviews. These include:
  - Major reviews held by both NSF and DOE prior to the MREFC award found the Basis of Estimate documentation to be quite adequate, with small improvements requested.
  - On May 7, 2014, the National Science Board (NSB) issued Resolution NSB-14-24, authorizing NSF management to proceed with the construction award, subject to the resolution of any substantive cost issues identified in the NSF review process. All cost issues were subsequently resolved, allowing the MREFC award to be issued in August 2014
  - The first annual construction review was originally scheduled for August-September 2015 but was deferred until February 2016. The review panel made several recommendations to improve project execution. To get back on schedule, the second progress review happened in August 2016 and was also successful, except that the Data Management (DM) systems were undergoing a major replan and could not be fully evaluated. A follow-up and successful DM-focused review took place in July 2017, providing support for significant use of cost contingency. The latest joint agency progress review occurred in September 2017.
  - In conjunction with the first progress review, NSF organized an Earned Value Management (EVM) validation review to consider both the adequacy of the system used for EVM, and the LSST Project staff's ability to use EVM tools and methods. The review made some minor recommendations, which were adopted. NSF formally accepted the LSST EVM system in January 2017. A follow-up EVM surveillance review coincided with the 2017 annual progress review.

  - In January 2017, DOE and NSF held a joint external agency review of the project's plans for commissioning and transition to early operations.
- After DOE Critical Decision (CD) reviews, DOE issued CD-3a approval for long-lead procurements in July 2014, and CD-2 approval, including setting the not-to-exceed Total Project Cost for the DOE sub-project, on January 7, 2015. CD-3 review in early August 2015 was followed by formal approval for full DOE construction funding on August 27, 2015.

Project Status

NSF's construction award was issued on August 1, 2014. Use of cost contingency and task-to-task float kept the project on the most optimistic schedule possible until recently, when delays with the main mirror cell have led to use of 10 weeks overall schedule contingency. Despite weather delays caused by an unprecedented El Niño event, the primary telescope building and dome installation will be completed in mid-FY 2018 and ready for the installation of necessary equipment and for the arrival of the telescope mount assembly. During the bid process, the estimated cost of the La Serena base facility was found to be in error, and some technical risk was realized. NSF has issued approval for the contract, and the approximately $4.0 million increase will be covered by available contingency. NSF- and DOE-supported activities remain tightly coordinated, both at the project level and between agency program officers.

Cost and Schedule

A complete re-estimate of the project occurred prior to the NSF FDR. The FDR panel found the NSF Total Project Cost (TPC) of $473.0 million to be reasonable and justifiable, but they nevertheless recommended that the project introduce possible additional de-scoping options. NSF carried out further cost review prior to making the award.

NSF policy changed from a probabilistic contingency estimation based on the Project Management Control System (PMCS) to requiring a joint cost and schedule Monte Carlo (MC) method. The LSST Project established the new MC method through their PMCS and showed that the computed TPC corresponds to a better than 90 percent chance that the final cost of the current construction scope will fall within the NSB-approved funding cap, and before the planned survey start date. This result was finalized in April 2015 and incorporated into the associated Cooperative Support Agreement.

In addition to NSF's contribution, DOE's baseline for the camera was fixed at $168.0 million by the CD-3 approval mentioned above. Construction also includes approximately $39.0 million from non-federal sources, all of which has been expended.

Risks

Technical: Much of the technical risk was retired during design and development. Since full construction began, no new major risks have appeared, and small, realized risks have been mitigated by use of cost and schedule contingency, including float internal to sub-projects. The Data Management construction effort has been identified as a risk and re-planning has been completed. Implementation of the recommendations of the July 2017 Data Management review, including the release of cost and schedule contingency, is currently underway.

Environmental and Cultural Compliance: Environmental and cultural impact mitigation continues as planned with no unforeseen issues.

Site: The possible site risk due to local geological anomalies, noted in previous requests, was realized during excavation. Since this risk was localized and anticipated, it was successfully handled. Site disruptions from geological events and extreme weather remain as possible risks with appropriate mitigation plans.

Environmental Health and Safety: The LSST project has a full-time head of safety with experience in AURA operations, which has a long positive safety record in Chile. Both the summit and base sites have on-site safety supervisors employed by LSST to monitor contractor and project activities. All safety plans are fully compliant with applicable standards from U.S., Chilean, and participating institutions, and are updated regularly. External reviews have given the project high marks for its safety culture.

Partnership Risk: Significant attention has been paid to partnership risk, and that risk has been mitigated by careful coordination and unified project structures. The LSST project director and deputy director oversee the entire project. A single project manager, agreed to by both NSF and DOE, manages the complete work breakdown structure elements. 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.

Operations Costs

Operation costs are funded within R&RA. The operations costs shown in the table immediately above are planning estimates based on the most recently available data. Although the FY 2019 Request is less than previous estimates, the overall 10-year operations cost estimate to NSF remains unchanged at $310.0 million (then-year US dollars). The final full operations costs and the amount required from non-federal partners will be determined through a review, approval, and award process that began with the project submission of a formal proposal for LSST operations in August 2017 and will include a review by the National Science Board in 2018 before the final award is issued.

In their joint Memorandum of Understanding, NSF and DOE agreed to fund operations, increasing agency support and revising the operations plans, as appropriate. MPS/AST is planning to provide approximately half of the original estimated steady-state amount, as well as pre-operations support, with the DOE Office of High Energy Physics providing one quarter, plus installation and commissioning support additional to the project construction cost. The project team has already established firm agreements to fund about half of the remaining one quarter with contributions from non-federal entities. Negotiations continue with potential partners to find the remaining balance.

Construction status on Cerro Pachón, November 2017. *Credit: LSST.*

THE NATIONAL ECOLOGICAL OBSERVATORY NETWORK (NEON) $0

No MREFC funds are requested for NEON in the FY 2019 Request. This narrative provides an update on the project's status.

Construction funding totals an estimated $469.30 million, which includes the $35.51 million increase in the Total Project Cost (TPC) established in 2016 in conjunction with the change in the managing organization. The increase in the TPC has been funded via transfers of R&RA funds from BIO. Roughly 88 percent of the approved project funds for construction have been spent, with Observatory capability at approximately 93 percent complete. Construction is expected to be complete by the fall of CY 2018. NEON operations and maintenance (O&M) will be funded through the R&RA account.

Appropriated and Requested MREFC Funds for the National Ecological Observatory Network
(Dollars in Millions)

	Prior Years	FY 2012 Actual	FY 2013 Actual	FY 2014 Actual	FY 2015 Actual	FY 2016 Actual	FY 2017 Actual	FY 2018 Request	FY 2019 Request	Total Project Cost[1]
Previous Funding Profile	$12.65	$60.30	$91.00	$93.20	$96.00	$80.64	-	-	-	$433.79
Revised Funding Profile	12.65	60.30	91.00	93.20	96.00	100.64	15.51	-	-	469.30
Change from Previous Profile	-	-	-	-	-	20.00	15.51	-	-	35.51
Appropriation Transfers	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*20.00*	*5.86*	-	-	*25.86*

[1] In June 2016, the National Science Board (NSB) approved an increase in NEON's Total Project Cost (TPC) from $433.79 million to $469.30 million. The $35.51 million increase was anticipated to be provided through transfers from the R&RA account to the MREFC account, at levels of $20.0 million in FY 2016 and up to $15.51 million in FY 2017. The full $20.0 million was transferred in FY 2016 but of the possible $15.51 million in FY 2017 funds, only $5.86 million was required and transferred from the R&RA account to the MREFC account.

The transfer from R&RA into MREFC so far has been less than the initial estimate of $35.51 million projected in FY 2016 because the project requirements, under the management of Battelle Memorial Institute, Inc. (Battelle), have been below the estimated levels. Of the planned $35.51 million R&RA transfer amount, only $25.86 million has been transferred to the MREFC account in two installments, $20.0 million in FY 2016 and $5.86 million in FY 2017. Several factors have accounted for the $9.65 million reduction from the anticipated level for the transfer, including lower than anticipated environmental compliance costs and updates to the estimated-to-complete (ETC), based on information that was not available when the TPC was revised in June 2016. Project requirements are being closely monitored by NSF to determine if any of the remaining $9.65 million of the approved transfer amount will be needed to complete the project.

Baseline History

NEON consists of geographically distributed field and lab infrastructure networked into an integrated research platform for regional to continental scale ecological research. Cutting-edge sensor networks, instrumentation, observational sampling, 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.

In 2004, the National Research Council 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 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 until construction began in August 2011.

Total Funding Requirements for NEON
(Dollars in Millions)

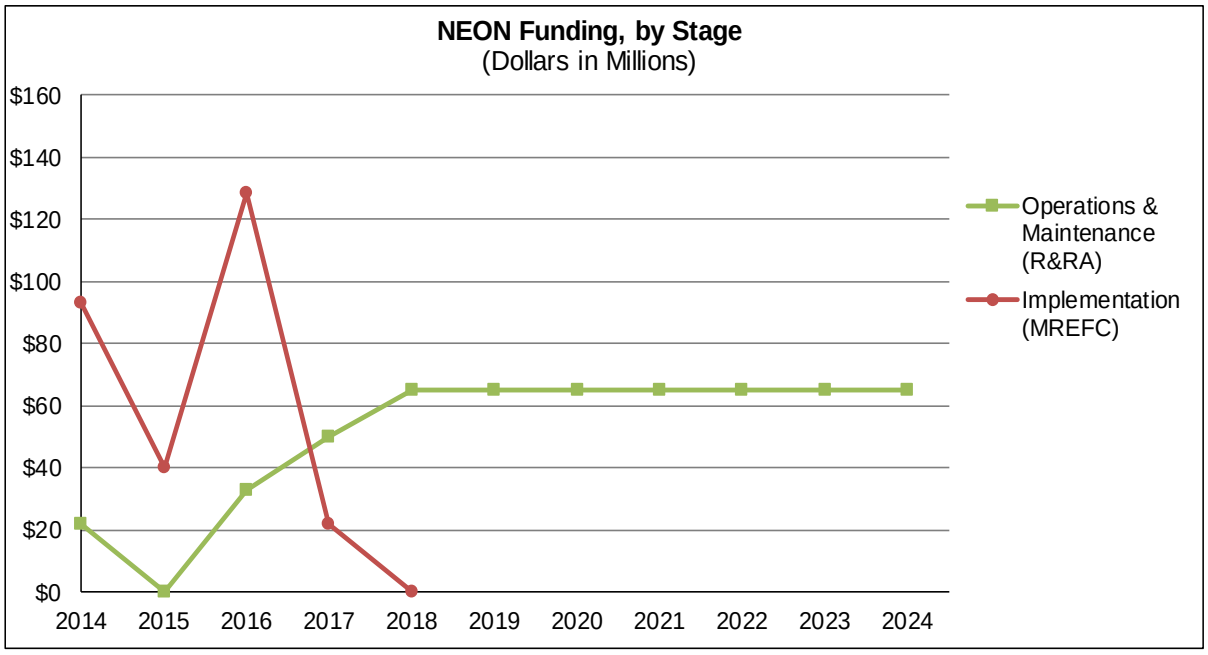
	Prior Years[1]	FY 2017 Actual	FY 2018 Request	FY 2019 Request	ESTIMATES FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
R&RA:									
Concept & Development	$104.85	-	-	-	-	-	-	-	-
Operations & Maintenance[2,3]	32.97	50.26	65.00	65.00	65.00	65.00	65.00	65.00	65.00
ARRA	9.96	-	-	-	-	-	-	-	-
Subtotal, R&RA	$147.78	$50.26	$65.00	$65.00	$65.00	$65.00	$65.00	$65.00	$65.00
MREFC:									
Implementation[3,4]	425.38	22.10	-	-	-	-	-	-	-
TOTAL REQUIREMENTS	**$573.16**	**$72.36**	**$65.00**	**$65.00**	**$65.00**	**$65.00**	**$65.00**	**$65.00**	**$65.00**

[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 O&M is currently capped at $65.0 million per year for planning purposes, pending the results from an initial period of operations under Battelle's management. Future O&M requests will be based on a more thorough analysis of science capabilities and affordability.

[3] In FY 2016, consistent with the revised TPC, $20.0 million of FY 2016 R&RA appropriated funding was transferred to the MREFC account. In FY 2017, $5.86 million of FY 2017 R&RA appropriated funding was transferred into the MREFC account.

[4] A total of $14.21 million of FY 2017 MREFC funding was carried over into FY 2018. Of this amount, $11.06 million will be obligated in FY 2018 to complete project construction requirements. The remaining $3.15 million is being held by NSF as management reserve and will only be obligated based on realized risks.



Note: $20.0 million in FY 2016 and $5.86 million in FY 2017 was transferred from the R&RA account to the MREFC account for NEON Implementation.

MREFC Project Plan

NEON is the first research platform and the only national experimental facility specifically designed to collect consistent and standardized sensor and biological measurements across 81 sites nationwide. This was reduced from 106 sites following NSF's decision in FY 2015 to de-scope the project in order to prevent a potential $80.0 million cost overrun. Measurements will enable 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 continental-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 are open-access via web portals and available as soon as possible, once basic quality assurance and quality control procedures have been applied.

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. 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 standalone system—federal or private—can provide the scientifically validated suite of data measurements that NEON will deliver. 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.

Management and Oversight

- NSF Structure: The NEON program is managed by the Division of Biological Infrastructure (DBI) within BIO. Managing the NEON program in DBI helps foster its associations with other BIO facilities and infrastructure investments and its connections to broader biological and interdisciplinary science activities. Within BIO/DBI, a Science Advisor (working with division leadership) provides overall programmatic oversight for BIO's mid- and large-scale research infrastructure, while the day-to-day program management is done by dedicated cognizant program officers with assistance from a project manager experienced with other MREFC projects. The cognizant program officers for construction and operations coordinate the direct oversight of NEON construction, operations and maintenance, and science utilization. An NSF Integrated Project Team (IPT) chaired by the NEON program officers, with representatives from the Office of Budget, Finance, and Award Management which includes the Large Facility Office, the Office of Legislative and Public Affairs, the Office of the Director, and program representatives from other NSF large facilities, helps ensure coordinated agency oversight to the project. The Office of the General Counsel provides ongoing technical advice on the National Environmental Policy Act (NEPA) compliance and NSF environmental policy and also has representation on the IPT. Additionally, NSF has initiated a forum for consultation with federal landowners at several NEON sites – the NEON Interagency Working Group (NIWG).
- External Structure: As of June 2016, the NEON project is managed by Battelle Memorial Institute, Inc. (Battelle), a non-profit, membership-governed corporation with extensive experience managing large research projects, government contracts, and related activities.

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. NSF signed a "Finding of No Significant Impact" 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.

- NSF conducted a Readiness Review to assess Battelle's competence to assume management of the NEON project in June of 2016.
- Construction, Cost, and Schedule reviews:
  - In June 2015 the NEON, Inc. estimate to complete included a projected cost overrun of $80.0 million above the approved budget. A baseline Re-Scope Review was held in July 2015 to assess reductions in scope to bring the costs within the approved budget in accordance with NSF's "No Cost Overrun" policy.
  - In July 2015, NSF directed NEON, Inc. to reduce the project scope and deliver revised project documents, construction schedule, and cost proposal to reflect the scope reduction.
  - A revised proposal was submitted December 2015 which indicated the potential for an additional $19.0 million cost overrun and further schedule slip leading NSF to make its decision to transfer management responsibility.
  - An independent cost estimate (ICE) was obtained by NSF to support its internal cost analysis and award to the new managing organization.
  - In June 2016 NSF conducted a site visit in order to review Battelle's readiness to assume full responsibility for the remaining construction and initial operations of the NEON Observatory.
  - A Construction and Transition to Operations Review will be conducted in CY 2018.
- National Science Board (NSB) Review: The NSB reviewed and authorized NEON construction in May 2010 and authorized initial NEON Operations and Maintenance (O&M) in February 2013. In September 2015, it established an ad hoc Task Force on NEON Performance and Plans to review and monitor NSF's oversight of the project. In 2016, after review of a new construction cost proposal (including the ICE), Battelle's successful management of the project to-date, and the remaining project risks, the NSB authorized an increase in the total project cost from $433.79 million to $469.30 million.
- Management, Business, and Operations Reviews:
  - NSF conducted a Business Systems Review 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.
  - Beginning in May 2015, NSF conducted a series of site visits to work with NEON, Inc., on improving business systems including reporting capabilities, cost sufficiency and estimation, and supply chain issues including procurement and contracting.
  - Delays in construction have impacted rollout of operations by one year. With the transition to Battelle, an extension of the initial operations award is anticipated to allow the project to stabilize. An external review of an extension of the initial operations funding was held in February 2017 with an associated site visit in March 2017. A pre-award financial review of the cost proposal was conducted in FY 2017.
  - An incurred cost review of the NEON, Inc. construction award will be conducted in FY 2019.
  - Annual Operations Reviews will continue once construction is complete.

Project Status

Ninety-three percent of the Observatory research capabilities have been achieved with one hundred percent capability planned to be completed by the fall of 2018. This includes construction for the remaining terrestrial locations and aquatic sites.

In FY 2018, carryover MREFC funds will support completion of components of NEON's assignable assets. This includes completion of the third Airborne Operations Platform (AOP3) and the Mobile Deployment Platforms (MDPs).

Scope Management and De-scoping: Delays in permitting of selected sites, cyberinfrastructure development, and procurements signaled the potential for significant construction cost overruns. Estimates

received in June 2015 prompted NSF to assemble leaders from the science community to assess possible scoping strategies for maintaining the project with the approved budget in accordance with NSF's no cost overrun policy. A major objective of the meeting was to ensure the delivered Observatory would still enable the transformative regional to continental science as framed in the original NEON Science Strategy. This decision to de-scope was confirmed by the NSF/BIO Advisory Committee. De-scoping decisions were finalized and implemented in late July 2015.

In FY 2018, $65.0 million was requested from the R&RA account to support NEON's operations and maintenance. The initial operations award, to NEON, Inc., that began in FY 2014 was transferred to Battelle in June 2016. Following NSB authorization, NSF has awarded additional funding for three years, which will take operations into FY 2020, allowing Battelle time to identify project efficiencies, minimize costs, and maximize science delivery. Final costs for observatory O&M will be determined on the basis of these management efforts and analyses.

Cost and Schedule

The original projected length of the construction stage was six fiscal years, with six-months of schedule contingency included. Under Battelle's management, the planned project end date is now estimated as the fall of CY 2018 and the TPC has been re-established as described above. Roughly 88 percent of the approved project funds for construction have been spent, with Observatory capability at approximately 93 percent complete. Focused management by Battelle and oversight by NSF continues to be rigorously implemented in an effort to keep the project within budget and on schedule.

Risks

Technical: 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 activities in the areas of sensors, cyberinfrastructure, and remote sensing technology. These development activities are progressing and risks to schedule are being monitored. Technical risk is considered low at this point in construction.

Deployment: Environmental assessment and permitting continues to have an impact on schedule. Risk mitigation strategies include the direct contracting of the environmental assessments by NSF, the hiring of experienced, national firms by Battelle for engineering and permitting, and the identification of alternative sites if primary sites still hold significant risk. All environmental compliance activities are actively underway and nearing resolution.

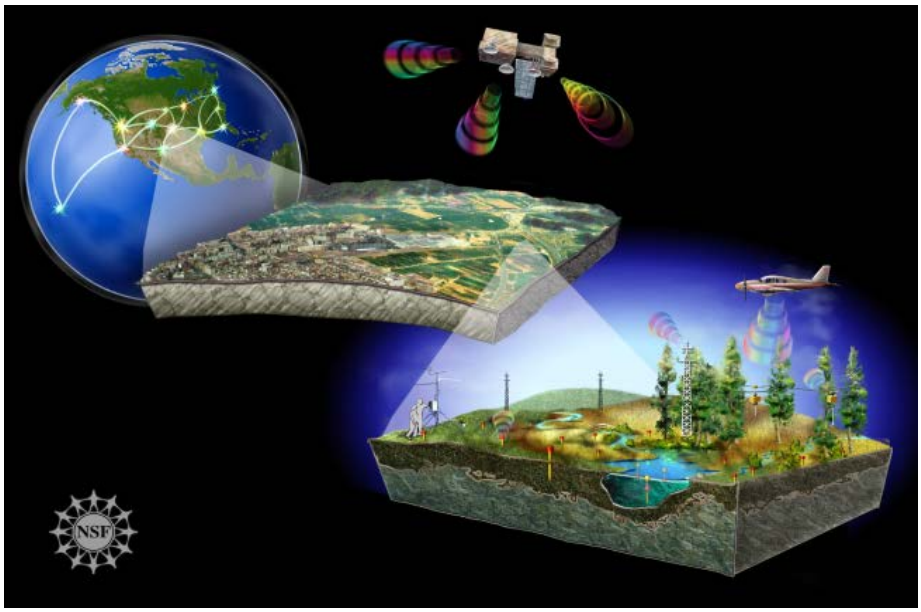
Management: Management risk has been mitigated by NSF based on the decision to replace NEON, Inc. with Battelle. The transition to new management is an inherently risky proposition but was necessary in this case. Battelle continues to work closely with NSF oversight personnel to clearly communicate process, standards, timelines, costs, and expectations.

Future Operations Costs

NEON is the first research observatory that will maintain and operate in-situ instrumentation and conduct biological sampling in 20 domains (81 locations) including three airborne observatories, a central operating facility, and a cyberinfrastructure center. Field support will be provided to monitor the sensors, and receive, process, and archive data from all measurement systems. NEON operations include significant labor costs due to the manual processes still required for biological sampling and data collection in some fields. 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 activities and associated costs will ramp up as sites are commissioned and the planned relocation of sites within domains is considered. Battelle is accelerating the transition of infrastructure to operations

whenever possible to appropriately manage construction costs.

A three-year initial award for O&M began September 2014 to allow NEON, Inc. to explore opportunities for schedule and cost efficiencies and provide a basis for funding the full Observatory operations during out-years. This award was transferred to Battelle in FY 2016. An extension of the initial operating period through FY 2019 under Battelle was authorized and awarded to allow the project to stabilize prior to re-competition. For FY 2019, O&M funding will be $65.0 million.



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.*

REGIONAL CLASS RESEARCH VESSELS (RCRV) **$28,700,000**

The FY 2019 Request for the Regional Class Research Vessel project is $28.70 million. The total project cost is $255.58 million. In FY 2017, P.L. 115-31 appropriated $121.88 million in funding to facilitate the planning and construction of three vessels. In the context of the President's overall fiscal goals intended to maintain spending restraint, this Budget Request supports construction of the two vessels.

Appropriated and Requested MREFC Funds
for the Regional Class Research Vessel Project
(Dollars in Millions)

	FY 2017 Actual	FY 2018 Estimate	FY 2019 Request	Total Project Cost
Current Funding Profile	$121.88	$105.00	$28.70	$255.58

In justification of their recommendation to NSF for the construction of RCRV, the 2015 National Academies of Sciences, Engineering, and Medicine (the National Academies) report, *Sea Change: 2015-2025 Decadal Survey of Ocean Sciences*,[5] described eight high-priority science questions that will be supported by RCRV in U.S. coastal waters:

1. What are the rates, mechanisms, impacts, and geographic variability of sea level change?
2. How are the coastal and estuarine ocean and their ecosystems influenced by the global hydrologic cycle, land use, and upwelling from the deep ocean?
3. How have ocean biogeochemical and physical processes contributed to today's climate and its variability, and how will this system change over the next century?
4. What is the role of biodiversity in the resilience of marine ecosystems and how will it be affected by natural and anthropogenic changes?
5. How different will marine food webs be at mid-century? In the next 100 years?
6. What are the processes that control the formation and evolution of ocean basins?
7. How can risk be better characterized and the ability to forecast geohazards like mega-earthquakes, tsunamis, undersea landslides, and volcanic eruptions be improved?
8. What is the geophysical, chemical, and biological character of the subseafloor environment and how does it affect global elemental cycles and understanding of the origin and evolution of life?

Baseline History

The RCRV project is a major component in the plan for modernizing the U.S. Academic Research Fleet (ARF).[6] In 2001, a report from the Federal Oceanographic Facilities Committee documented the need for Regional Class vessels. In 2004, NSF and the Naval Sea Systems Command (NAVSEA) entered into an interagency agreement that resulted in two candidate designs for Regional Class ships. In 2007, the Federal Oceanographic Fleet Status Report identified the need for NSF-built Regional Class vessels to meet future science demand. In 2009, another National Academies report, Science at Sea, described the desirable characteristics of a modern Regional Class vessel. These characteristics and other science community factors were considered by the review panel when the preferred NAVSEA design was later down-selected. In 2012, NSF issued a solicitation for the refreshed design and potential construction of RCRV. Oregon State University (OSU) was selected and received the award in 2013. Input from external review panels, the University-National Oceanographic Laboratory System (UNOLS), and the NAS Sea Change report, was received during the period 2013 to 2015 and informed the final decision to pursue construction. In

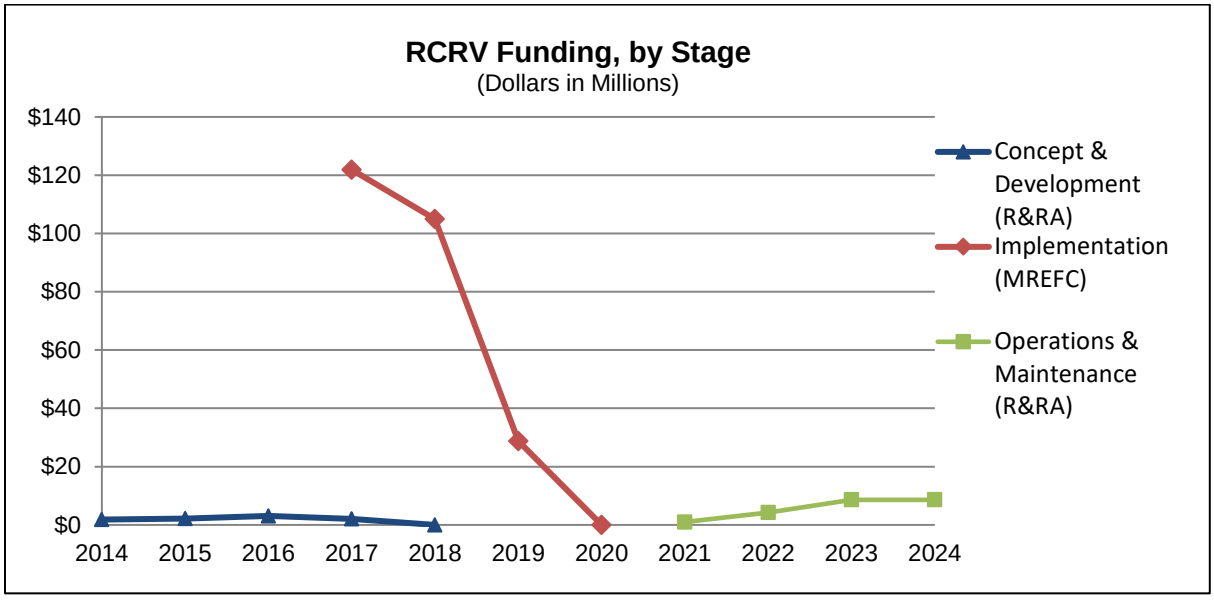
[5] The National Academies of Science. Sea Change: 2015-2025 Decadal Survey of Ocean Sciences, 2015. www.nap.edu/read/21655/chapter/1

[6] National Ocean Council. Federal Oceanographic Fleet Status Report, 2013. https://obamawhitehouse.archives.gov/sites/default/files/federal_oceanographic_fleet_status_report.pdf

2015, the National Science Board authorized inclusion of funds to initiate construction for the RCRV project in future budget requests at the NSF Director's discretion. The Final Design Review was conducted in December 2016 and the panel recommended to NSF that the project was ready to advance to the construction stage. OSU awarded a contract for construction to Gulf Island Shipyards, Houma, LA. NSF plans to fund the operations of the RCRVs without increasing overall fleet costs, which is a result of fleet right-sizing and modernization.

Total Funding Requirements for RCRV
(Dollars in Millions)

	Prior Years	FY 2017 Actual	FY 2018 Estimate	FY 2019 Request	ESTIMATES FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
R&RA:									
Concept & Development	$9.82	$2.11	-	-	-	-	-	-	-
Operations & Maintenance	-	-	-	-	-	1.00	4.30	8.60	8.60
Subtotal, R&RA	$9.82	$2.11	-	-	-	$1.00	$4.30	$8.60	$8.60
MREFC:									
Implementation	-	121.88	105.00	28.70	-	-	-	-	-
Subtotal, MREFC	-	$121.88	$105.00	$28.70	-	-	-	-	-
TOTAL REQUIREMENTS	**$9.82**	**$123.99**	**$105.00**	**$28.70**	**-**	**$1.00**	**$4.30**	**$8.60**	**$8.60**



Management and Oversight

- NSF Structure: The RCRV project is overseen by the Division of Ocean Sciences (OCE) as part of the Ship Acquisition and Upgrade Program. OCE provides overall interdisciplinary science community guidance and oversight, while the administrative location of the RCRV project in the Integrative Programs Section promotes science facilities support expertise and coordination. Within NSF, RCRV project oversight is managed by a dedicated program officer with support from a secondary program officer who has experience with other OCE facilities. Cross-foundation coordination is provided by an integrated project team (IPT). The IPT includes staff from the Office of Budget, Finance, and Award Management (BFA), BFA Large Facilities Office, BFA Division of Acquisition and Cooperative Support, BFA Division of Institution and Award Support, Office of the Director, Office of the General Counsel, Office of the Assistant Director for Geosciences, and Office of Legislative and Public Affairs.

- External Structure: The RCRV project is funded through a series of cooperative agreements with OSU to manage the design refresh (Conceptual, Preliminary, and Final Designs), construction, testing and trials, and eventual operation of the first RCRV for the scientific community. The principal investigator for the award is the project manager (PM), who reports directly to the OSU Dean of the College of Earth, Ocean and Atmospheric Sciences. The PM interacts directly with NSF and manages the RCRV administrative staff. The project scientist is a co-Principal Investigator on the award. The PM manages the core RCRV team including the risk manager, earned value management and schedule specialist, contracting officer, and OSU shipyard representative (SR). The SR in turn manages the naval architect and engineering contract and oversees the OSU shipyard staff, and marine science technical advisors. The RCRV Science Oversight Committee (SOC) with regional representation, multidisciplinary expertise, and independent science representatives conducting research in mission areas supported by stakeholder federal agencies (e.g., NSF, Office of Naval Research, and the National Oceanic and Atmospheric Administration will be active through all project phases. The SOC provides guidance to the OSU RCRV project team through the PM and/or the NSF program officer.

Reviews

- Proposal Review: In 2012, NSF issued Solicitation 12-558, Construction of Regional Class Research Vessels, to select a lead institution for construction and ship operations. An NSF external review panel was convened to evaluate three proposals, and OSU was selected.
- Interim Design Review (IDR): Although an Interim Design Review was not required by NSF, OSU hosted its own IDR on July 23-25, 2013, in Corvallis, OR. NSF program staff assessed the OSU project team performance and concluded the IDR followed closely the NSF requirements, and used the R/V Sikuliaq example, as appropriate, to craft the RCRV Project Execution Plan (PEP). Both the design and the PEP were well-developed at this pre-Conceptual Design Review phase; particularly the organizational structure, work breakdown structure (WBS), risk management, and configuration and contingency management.
- Conceptual Design Review (CDR): CDR was conducted December 3-5, 2013, at NSF Headquarters in Arlington, VA. The NSF program staff concurred with the panel's conclusion that the Project Execution Plan and Technical Design Package met, and in some cases exceeded, the requirements of the Conceptual Design Phase.
- Preliminary Design Review (PDR): PDR was conducted August 5-7, 2014, at NSF Headquarters. The panel found that the Project Execution Plan and the technical design package were both well-developed to support a future budget request and recommended that the project proceed to the Final Design Phase.
- Post-PDR Reconciliation: Following PDR, in response to the panel recommendations and NSF program staff direction, OSU incorporated modifications to the design and revised their estimated project costs and schedule accordingly. The NSB was presented with the post-PDR Project baseline as the basis for their authorization to request funding for RCRV in future budget requests.
- Acquisition Strategy Review: A review of all aspects of the shipyard selection process was held in February 2016, at NSF. NSF directed OSU to make minor revisions to the Request for Proposals (RFP) based on the review.
- Interim Design Review: A second IDR was held by OSU in May 2016. Although not required, the value of the previous IDR for improvement to the technical package and the Project Execution Plan was sufficient that another IDR to prepare for FDR was warranted. The review was hosted by the RCRV Project Team in Corvallis, OR, and attended by NSF program staff as well as the RCRV SOC. The SOC provided minor technical improvements to the RCRV, which were incorporated into the RFP.
- Final Design Review (FDR): The FDR was held in December 2016 to ensure that anticipated project costs remained realistic and that no unforeseen events had arisen prior to the start of construction during FY 2017. Several members of the PDR panel also participated in the FDR. Like CDR and PDR, FDR was conducted in compliance with NSF's Large Facilities Manual. The FDR Panel recommended to NSF that the project was ready to advance to the Construction Stage.

Project Status
As stated above, NSF selected OSU as the lead institution. A cooperative agreement was awarded to encompass the entire project, including tests and trials. The project is divided into four distinct phases, each to be funded through separate cooperative support agreements, with award of each phase contingent upon successful completion of the prior phase. These phases are:

Phase I: Project Refresh (Years one to three)
Phase II: Shipyard Selection (Year four)
Phase III: Construction (Years five through eight)
Phase IV: Transition to Operations (Years eight and nine)

The project completed Phase II in CY 2017, during which bids for construction of RCRV were solicited and evaluated from U.S. shipyards. The Phase III construction award with OSU has been made. Total funding to OSU for RCRV through FY 2017 is $11.39 million in R&RA funds and $121.88 million in MREFC funds. The remaining required funding for the construction of two ships is $105.0 million in FY 2018 and $28.70 in FY 2019 for a total of $255.58 million in MREFC funding.

Cost and Schedule
The length of the project is projected to be eight fiscal years, including nine-months of schedule contingency. Funding for the construction of RCRV over FY 2017, FY 2018, and FY 2019 supports the shipyard contract structure.

One significant enhancement to NSF oversight is holding a portion of budget contingency (up to 100 percent) and only allocating to the program, for obligation to the project, based on demonstrated need. This oversight mechanism will generally result in some MREFC carry over each year, however, future obligation is anticipated to manage project risks.

Risks
Technical: The following technical risks are among the principal risks that were identified and listed on OSU's project risk register. Planned mitigation strategies are included here with each identified risk. (1) Various situations may occur that could delay or add cost to OSU's management portion of the project. These include delayed appointments of key personnel, contracting issues, lack of management capacity due to optimistic planning, or misunderstanding of requirements. (2) Sonar sensors, science load handling systems, and other vessel sub-systems may also not perform as required. Contingency funds are included to ensure performance capabilities are met, given that many warranties are not likely to be performance-based or be otherwise limited contractually with the shipyard. (3) Growth in weight and vertical center of gravity may require design changes in order to ensure vessel seaworthiness. This is a typical risk for ship construction (and research vessels in particular) that will require active management by OSU and the shipyard, as well as oversight by NSF, such that the ship can operate safely and effectively. A science prioritized, time-phased de-scoping plan is in place (per NSF Large Facilities Manual, NSF17-066) to minimize impacts to science capabilities in case contingency funds are insufficient to cover realized risks.

Future Operations Costs
Annual ship operations costs are well understood after several decades of experience with vessels of all types in the U.S. Academic Research Fleet. OSU understands how to estimate future costs given their experience operating vessels similar to RCRV, such as R/V Wecoma and R/V Oceanus. OSU included an estimate for the first year of operations beginning in 2021 using reasonable assumptions for escalations through 2020. They also assumed a robust but reasonable operating schedule of 200 days per year. OSU estimates RCRV will cost $6.10 million to operate in its first year, resulting in a rate of $30,441 per day, including technician support. This is comparable to the operation of current similar vessels after applying the appropriate cost escalation factors for size and complexity. NSF supports approximately 70 percent of

the use of the U.S. Academic Research Fleet, which suggests RCRV is likely to cost NSF approximately $4.30 million in FY 2022, which is the first year the lead ship transitions into full operations in the ARF. A solicitation for operations of additional vessels beyond the first RCRV operated by OSU was released in January 2018.

Artist's rendition of the RCRV as constructed. *Credit: The Glosten Associates Inc.*

ORGANIZATIONAL EXCELLENCE **$485,850,000**
-$42,430,000 / -8.0%

Organizational Excellence Funding Summary
(Dollars in Millions)

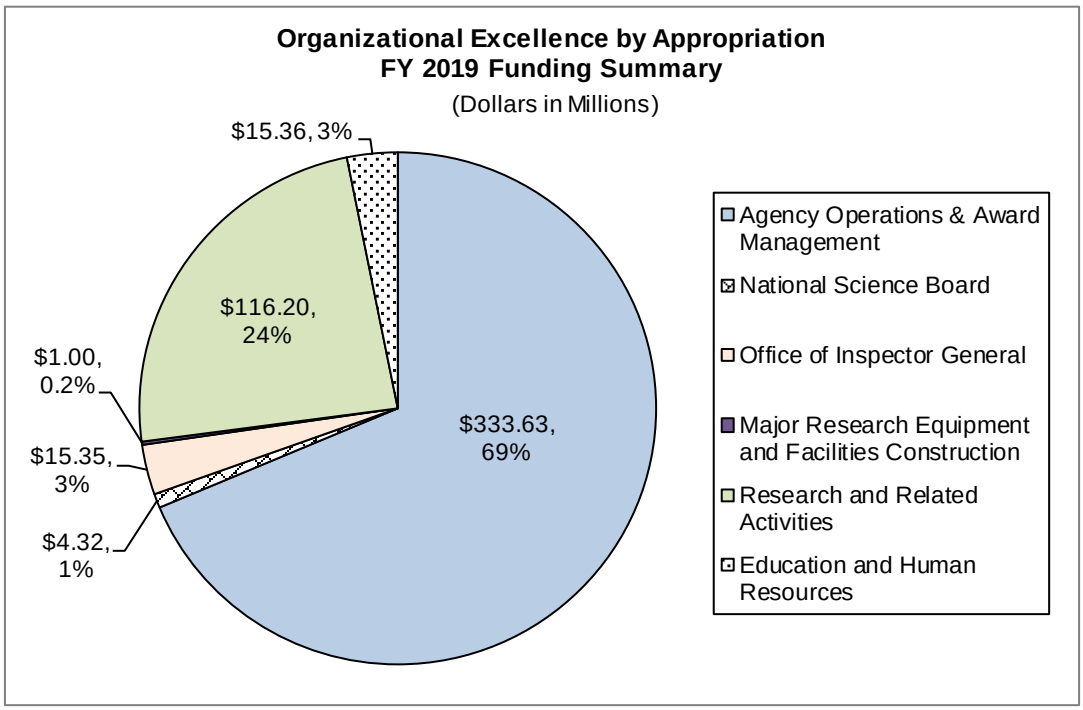
FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Percent
$528.28	-	$485.85	-$42.43	-8.0%

NSF's FY 2019 funding for Organizational Excellence is $485.85 million. NSF's management objectives have the goal of achieving organizational excellence through a continuous emphasis on efficiency and efficacy, as noted under Strategic Goal 3 of the NSF Strategic Plan for 2018-2022[1] - Enhance NSF's Performance of its Mission. The portfolio of activities included in Organizational Excellence addresses the agency's operations and administrative functions, which underpin NSF's programmatic activities. These activities are critical to the accomplishment of the agency's other two strategic goals, Expand Knowledge in Science, Engineering and Learning, and Advance the Capability of the Nation to Meet Current and Future Challenges.

An overview of the various activities that are included in the Organizational Excellence portfolio is included in this summary. Also included in this discussion is information on the E-Government initiatives to which the agency contributes. The two tables on the following pages show first the Organizational Excellence portfolio by appropriation, and second the portfolio by its components—Human Capital, Travel, Information Technology (IT), Administrative Support, Major Research Equipment and Facility Construction (MREFC) Oversight, and support for the National Science Board (NSB) and the Office of Inspector General (OIG)—along with their funding sources, as several are funded through more than one appropriation.

As part of its Agency Reform Plan, NSF will initiate operational reforms in four areas in FY 2019: (1) make information technology work for us, (2) align NSF's workforce and work, (3) expand public and private partnerships, and (4) streamline, standardize, and simplify programs and processes. NSF will work to ensure that IT tools enhance employee productivity and satisfaction by enabling access to readily available, reliable, and fully integrated data that supports decision making. NSF will also invest an additional $4.0 million in IT modernization. NSF will optimize the alignment of staffing and position descriptions with the changing landscape. NSF will maintain its already lean workforce through continuous improvements in personnel training and utilization, and through effective performance management. NSF will improve efficiencies in developing, implementing, and managing partnerships that maximize the scientific, economic, and societal impacts of its investments. NSF will also revise policies and business processes to increase standardization across NSF organizations and eliminate unnecessary complexity. These Agency reforms will allow NSF to continue to achieve its mission within a constantly evolving landscape in alignment with NSF's history of continued organizational improvement, and the Administration's government-wide agency reform activities. More information on NSF's Agency Reform Plan can be found in the Overview section.

[1] NSF (2018). Building the Future: Investing in Discovery and Innovation – NSF Strategic Plan for Fiscal Years (FY) 2018-2022. Retrieved from: www.nsf.gov/about/performance/strategic_plan.jsp



Organizational Excellence by Appropriation
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Percent
Agency Operations & Award Management	$382.06	-	$333.63	-$48.44	-12.7%
National Science Board	4.27	-	4.32	0.05	1.2%
Office of Inspector General	15.10	-	15.35	0.25	1.6%
Major Research Equipment and Facilities Construction	0.33	-	1.00	0.67	207.3%
Program Support:					
Research and Related Activities	110.87	-	116.20	5.33	4.8%
Education and Human Resources	15.65	-	15.36	-0.29	-1.8%
Subtotal, Program Support	*126.52*	*-*	*131.56*	*5.04*	*4.0%*
Total	**$528.28**	**-**	**$485.85**	**-$42.43**	**-8.0%**

Organizational Excellence by Major Component

The table below shows the major components of Organizational Excellence. This table also shows the funding sources for the major components and activities, as several are funded through more than one appropriation.

Organizational Excellence by Major Component
(Dollars in Millions)

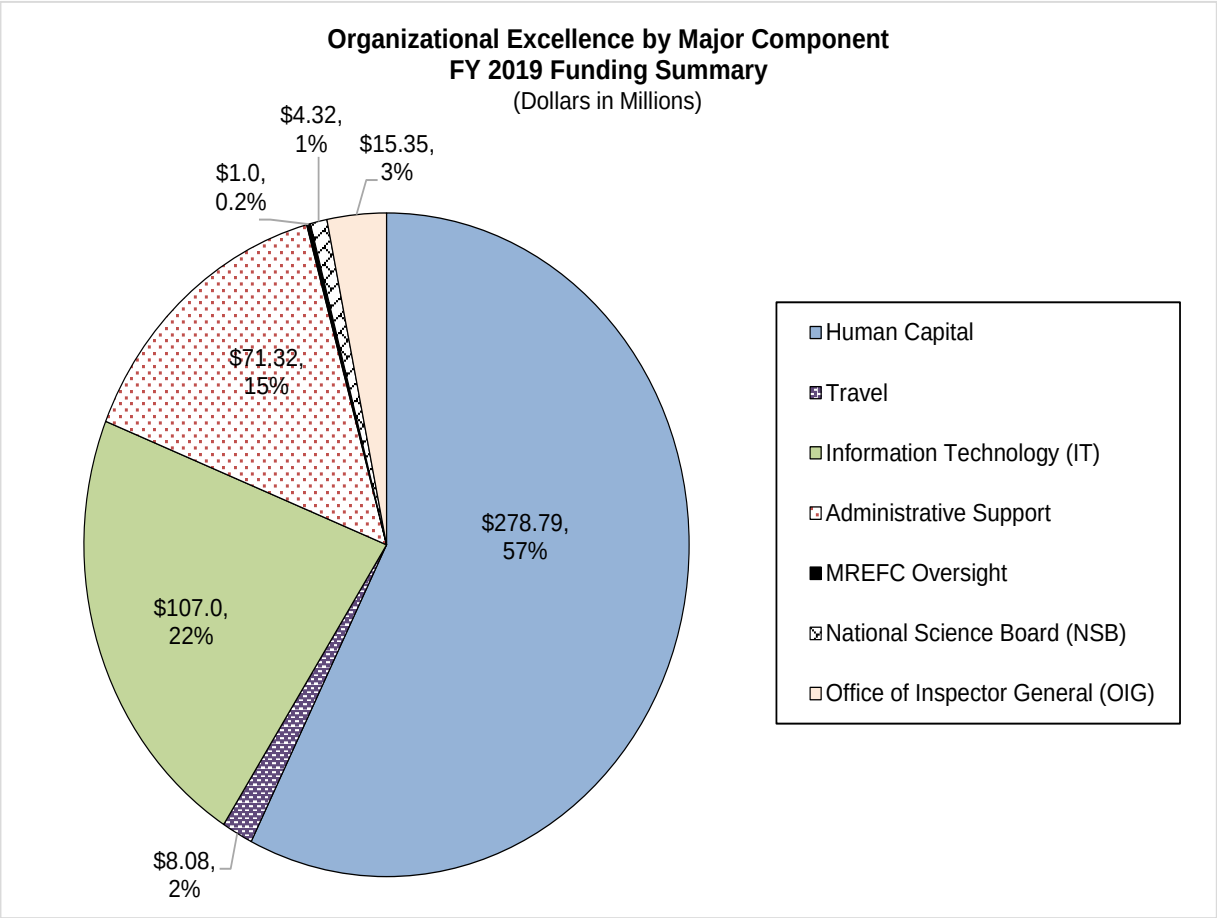
	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent	Funding Source
Human Capital	$268.98	-	$278.79	$9.81	3.6%	
Personnel Compensation & Benefits[1]	220.76	-	229.71	8.94	4.1%	AOAM
Management of Human Capital	10.28	-	10.11	-0.18	-1.7%	AOAM
IPA Appointments	37.94	-	38.98	1.04	2.8%	
Compensation	34.73	-	35.81	1.08	3.1%	RRA/EHR
Lost Consulting & Per Diem	3.21	-	3.17	-0.04	-1.1%	RRA/EHR
Travel	$8.11	-	$8.08	-$0.03	-0.4%	
NSF Federal Employee Staff	5.53	-	5.45	-0.08	-1.4%	AOAM
IPA Appointments	2.58	-	2.63	0.05	1.8%	RRA/EHR
Information Technology (IT)	$107.60	-	$107.00	-$0.60	-0.6%	
Agency Operations IT	31.32	-	26.20	-5.12	-16.3%	AOAM
Administrative Applications Services and Support	6.64	-	7.10	0.46	6.9%	AOAM
Administrative Infrastructure Services and Support	21.13	-	15.26	-5.87	-27.8%	AOAM
Administrative Security and Privacy Services and Support	3.03	-	3.33	0.30	9.8%	AOAM
Administrative IT Management	0.51	-	0.51	-	-	AOAM
Program Related Technology (PRT)	76.28	-	80.80	4.52	5.9%	RRA/EHR
Mission-Related Applications Services	50.29	-	51.96	1.68	3.3%	RRA/EHR
Mission-Related IT Operations and Infrastructure	19.78	-	21.62	1.84	9.3%	RRA/EHR
Mission-Related Security and Privacy Services	3.98	-	4.98	1.00	25.2%	RRA/EHR
Mission-Related IT Management	2.24	-	2.24	-	-	RRA/EHR
Administrative Support	$77.15	-	$71.32	-$5.83	-7.6%	
Space Rental	36.34	-	31.19	-5.15	-14.2%	AOAM
Operating Expenses	17.04	-	17.87	0.83	4.9%	AOAM
Building and Administrative Services	14.05	-	13.10	-0.95	-6.8%	AOAM
Other Program Related Administration	7.63	-	3.65	-3.98	-52.1%	RRA/EHR
Evaluation and Assessment Capability[2]	4.71	-	-	-4.71	-100.0%	RRA/EHR
Proposal Management Efficiencies[3]	0.32	-	-	-0.32	-100.0%	RRA/EHR
E-Government Initiatives	1.44	-	1.50	0.06	4.2%	RRA/EHR
General Planning and Evaluation Activities	1.16	-	2.15	0.99	85.5%	RRA/EHR
Other Organizational Excellence Activities	2.09	-	5.50	3.41	162.7%	
Evaluation and Assessment Capability	[4.71]	-	3.00	-1.71	-36.3%	RRA-IA
Planning and Policy Support	2.09	-	2.50	0.41	19.4%	RRA-IA
MREFC Oversight[4]	$0.33	-	$1.00	$0.67	207.3%	MREFC
NSF Headquarters Relocation	$46.74	-	-	-$46.74	-100.0%	AOAM
National Science Board (NSB)	$4.27	-	$4.32	$0.05	1.2%	NSB
Office of Inspector General (OIG)	$15.10	-	$15.35	$0.25	1.6%	OIG
Total, Organizational Excellence	**$528.28**	**-**	**$485.85**	**-$42.43**	**-8.0%**	

[1] Funding levels for PC&B reflect direct appropriated funds only. In FY 2017, $4.19 million in Administrative Cost Recoveries (ACRs) were received bringing the total PC&B obligation to $224.95 million. Approximately $5.48 million in ACRs are expected in FY 2019 to meet the total PC&B requirement of $235.19 million.

[2] In the FY 2018 Request, EAC was moved from Other Program Related Administration to a line item in the IA budget within the R&RA account. FY 2017 Actual funding is shown under Other Organizational Excellence Activities for comparability.

[3] For the FY 2019 Request, $920,000 for Proposal Management Efficiencies (PME) is moved from Other Program Related Administration to Planning and Policy Support, a line item in the IA budget within the R&RA account.

[4] MREFC funding for oversight activities is added to the Organizational Excellence budget beginning in FY 2019.



1. Human Capital: The FY 2019 funding amount for Human Capital is $278.79 million. The Human Capital component includes personnel compensation and benefits of NSF's federal employees as well as support for NSF's temporary employees—both those that are hired through authority provided by the Intergovernmental Personnel Act, known as IPAs, and those employed through NSF's own Visiting Scientist, Engineer, and Educator (VSEE) program. NSF's federal employee full-time equivalents (FTE) and VSEEs 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) and Education and Human Resources (EHR).

The use of IPAs and VSEEs, together 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. VSEEs count as regular federal FTE and are included in the regular AOAM FTE totals. IPAs are not included in the regular AOAM FTE totals.

NSF Workforce:
The table below shows the agency's total workforce for FY 2019.

NSF Workforce
Full-Time Equivalents (FTE)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
AOAM FTE Allocation					
Regular	*1,310*	-	*1,310*	-	-
Pathways Intern[1]	*42*	-	*42*	-	-
Subtotal, AOAM FTE Allocation	*1,352*	-	*1,352*	-	-
AOAM FTE Usage (Actual/Projected)					
Regular	1,309	-	1,310	1	0.1%
Pathways Interns[1]	28	-	42	14	48.4%
Subtotal, AOAM FTE	1,337	-	1,352	15	1.1%
Office of the Inspector General	72	-	71	-1	-1.4%
National Science Board	18	-	19	1	5.6%
Arctic Research Commission	3	-	3	-	-
Total, Federal Employees (FTE)	1,430	-	1,445	15	1.0%
IPAs (FTE)	174	-	171	-3	-1.4%
Detailees to NSF	3	-	3	-	-
Total, Workforce	**1,607**	**-**	**1,619**	**12**	**0.8%**

[1] The Pathways Intern 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).

A discussion of NSF's FTE allocation and usage is included in the Personnel Compensation and Benefits (PC&B) section of the AOAM chapter. A more detailed discussion about IPAs is included in the Program Accounts: R&RA and EHR chapter. The OIG, NSB, and U.S. Arctic Research Commission (USARC) chapters include a discussion of their respective workforces.

The Human Capital component also includes support for the Management of Human Capital, which is discussed in the AOAM chapter.

2. Travel: The FY 2019 Request for staff and IPA travel is $8.08 million. Staff travel accounts for about 67 percent of this total at a level of $5.45 million in FY 2019 and is provided from the AOAM account. Travel for IPA appointments, which is supported by the R&RA and EHR accounts, is $2.63 million. For more detailed information about NSF staff and IPA travel funding, see the AOAM and Program Accounts: R&RA and EHR chapters, respectively.

3. Information Technology (IT): NSF's FY 2019 Request for IT investments total $107.0 million. Funding for NSF's IT investment is provided from the AOAM, R&RA, and EHR accounts.

IT Investments by Appropriation
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Agency Operations & Award Management (AOAM)	$31.32	-	$26.20	-$5.12	-16.3%
Program Related Technology (PRT)	76.28	-	80.80	4.52	5.9%
Research and Related Activities (R&RA)	*64.93*	*-*	*70.30*	*5.37*	*8.3%*
Education and Human Resources (EHR)	*11.35*	*-*	*10.50*	*-0.85*	*-7.5%*
Total	**$107.60**	**-**	**$107.00**	**-$0.60**	**-0.6%**

Agency IT investments funded through the AOAM account support the agency's operations to ensure high quality, reliable, and secure administrative applications and associated IT infrastructure support and services to meet the needs of the Foundation. This funding accounts for about 24 percent of NSF's total IT investment in the FY 2019 Request. Additional detail regarding the AOAM funded IT investments can be found in the AOAM chapter.

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 are mission-related IT investments that 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. Included in this is a $4.0 million investment in IT modernization as part of NSF's Agency Reform Plan. PRT investments account for 76 percent of NSF's FY 2019 Request for IT investments. More information on PRT can be found in the Program Accounts: R&RA and EHR chapter.

4. Administrative Support: FY 2019 funding for Administrative Support is $71.32 million. Included in this amount are funds for agency implementation of sustainability goals outlined in NSF's Strategic Sustainability Performance Plan, in association with meeting the goals of E.O. 13693. The activities that comprise NSF's FY 2019 Administrative Support are:

- Space Rental at $31.19 million. More detailed information about Space Rental can be found in the AOAM chapter.
- Operating Expenses ($17.87 million) includes funding for various financial and award management and leadership activities such as post-award monitoring; contract close-out activities; large facility oversight; improper payments, financial statement, and internal controls reporting; Committee on Equal Opportunities in Science and Engineering (CEOSE) activities; NSF's Enterprise Information System; and supplies, equipment, and training which are necessary for the accomplishment of NSF's mission. A detailed discussion about Operating Expenses can be found in the AOAM chapter.
- Building and Administrative Services ($13.10 million) includes administrative contracts that support NSF's facilities and business operations, administrative services, and infrastructure such as security system maintenance, ID issuance, continuity of operations support services, and Federal Register notices for panels and advisory committees. A detailed discussion of these activities can be found in the AOAM chapter.
- Other Program Related Administration (PRA) is funded at $3.65 million to support general Planning and Evaluation activities, which include agency-wide efforts such as the verification and validation of performance information, and E-Government efforts. A detailed discussion about Other PRA can be found in the Program Accounts: R&RA and EHR chapter.
- Other Organizational Excellence Activities ($5.50 million) funds the Evaluation and Assessment Capability (EAC) and Planning and Policy Support—two NSF-wide activities managed by the Office

of Integrative Activities (OIA). For more information on EAC or Planning and Policy Support, see the IA narrative in the RRA chapter.

5. Major Research Equipment and Facilities Construction (MREFC) Oversight: The FY 2019 Request includes $1.0 million for oversight of NSF's major facility projects. For more information on this activity, see the MREFC chapter.

6. NSF Headquarters Relocation: NSF has completed the move of its headquarters to the new building in Alexandria, VA. No funding is requested for this activity in FY 2019.

7. National Science Board (NSB): The staffing and operations of the NSB office are supported through a separate NSB appropriation. Details about the NSB FY 2019 Request can be found in the NSB chapter.

8. Office of Inspector General (OIG): The staffing and operations of the OIG are supported through a separate OIG appropriation. Details about the OIG FY 2019 Request can be found in the OIG chapter.

NSF FY 2019 Request Funding for E-Government Initiatives

The table below shows NSF's contributions and service fees for various E-Government initiatives. The FY 2019 levels are consistent with the funding amounts provided by the initiatives' respective managing partners.

NSF FY 2019 Request Funding for E-Government Initiatives

	FY 2019			Appropriations Account	
Initiative	Agency Contribution	Agency Svc. Fees	NSF Total	AOAM	R&RA
Grants.gov	$233,849	-	$233,849	-	$233,849
E-Travel	-	184,467	184,467	184,467	-
Geospatial LoB	25,000	-	25,000	-	25,000
E-Training	-	370,000	370,000	370,000	-
E-Rulemaking	-	19,862	19,862	19,862	-
USA Jobs	-	10,350	10,350	10,350	-
E-Human Resource Integration	-	24,634	24,634	24,634	-
Integrated Acquisition Environment	-	944,275	944,275	21,000	923,275
Human Resources Management LoB	68,478	-	68,478	-	68,478
Financial Management LoB	139,094	-	139,094	-	139,094
Budget Formulation/Execution LoB	110,000	-	110,000	-	110,000
E-Payroll (incl. Shared Services)	-	314,640	314,640	314,640	-
Total	**$576,421**	**$1,868,228**	**$2,444,649**	**$944,953**	**$1,499,696**

LoB: Line of Business

PROGRAM ACCOUNTS: R&RA AND EHR **$131,560,000**
+$5,040,000 / 4.0%

Funding from program accounts Research and Related Activities (R&RA) and Education and Human Resources (EHR) covers approximately 27 percent of the total Organizational Excellence portfolio. Three activities comprise program-funded Organizational Excellence: Intergovernmental Personnel Act (IPA) costs, Program Related Administration, and Other Organizational Excellence Activities.

Summary of R&RA- and EHR-Funded Organizational Excellence
(Dollars in Millions)

	FY 2017 Actual	FY 2018 Request	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
IPA Costs	**$40.52**	**-**	**$41.61**	**$1.09**	**2.7%**
IPA Compensation	34.73	-	35.81	1.08	3.1%
IPA Lost Consulting & Per Diem	3.21	-	3.17	-0.04	-1.1%
IPA Travel	2.58	-	2.63	0.05	1.8%
Program Related Administration	**$83.91**	**-**	**$84.45**	**$0.54**	**0.6%**
Program Related Technology	76.28	-	80.80	4.52	5.9%
Other Program Related Administration[1,2]	7.63	-	3.65	-3.98	-52.1%
Other Organizational Excellence Activities	**$2.09**	**-**	**$5.50**	**$3.41**	**162.7%**
Evaluation and Assessment Capability (EAC)[2]	-	-	3.00	3.00	N/A
Planning and Policy Support[1]	2.09	-	2.50	0.41	19.4%
Total, R&RA and EHR Funded Organizational Excellence	**$126.52**	**-**	**$131.56**	**$5.04**	**4.0%**

[1] For the FY 2019 Request, $920,000 for Proposal Management Efficiencies (PME) is moved from Other Program Related Administration to Planning and Policy Support, a line item in the IA budget within the R&RA account.

[2] In the FY 2018 Request, EAC was moved from Other Program Related Administration to a line item in the IA budget within the R&RA account.

Intergovernmental Personnel Act (IPA) Costs

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 at NSF during their temporary appointment. They are not paid directly by NSF and are not subject to federal pay, benefits, or other limitations. NSF reimburses their home institution without overhead. IPAs are eligible to receive relocation expenses, or a per diem allowance in lieu of relocation. Reimbursement for income foregone because of their assignment at NSF is allowed only for IPA agreements in place before FY 2017, per NSF's new policy released October 2016. In addition, the new policy is piloting a required 10 percent cost sharing by the IPA's home institution of the IPA's academic-year salary and fringe benefits.

The agency uses IPA 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.

IPA Costs by Appropriation
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
IPA FTE Utilization[1]	174	-	171	-3	-1.4%
Research and Related Activities (R&RA)					
IPA Compensation	$31.02	-	$31.95	$0.93	3.0%
IPA Lost Consulting & Per Diem	2.83	-	2.80	-0.03	-1.2%
Travel	2.37	-	2.42	0.05	2.0%
Subtotal, R&RA Costs	**$36.23**	**-**	**$37.17**	**$0.94**	**2.6%**
Education and Human Resources (EHR)					
IPA Compensation	3.71	-	3.86	0.15	4.0%
IPA Lost Consulting & Per Diem	0.37	-	0.37	-	-
Travel	0.21	-	0.21	-	-
Subtotal, EHR Costs	**$4.29**	**-**	**$4.44**	**$0.15**	**3.5%**
Total, IPA Costs[1]	**$40.52**	**-**	**$41.61**	**$1.09**	**2.7%**

[1] FY 2017 Actual utilization and total obligations include the costs associated with approximately three IPA FTE in the Office of Budget Finance and Award Management and the Office of the Director. These three FTE are included in the 171 IPA FTE for FY 2019; however, the funding for these three IPA FTE (approximately $300,000) is budgeted within Other Program Administration and included in the General Planning and Evaluation (P&E) activities section of this narrative.

The FY 2019 Request funding for IPA costs is $41.61 million representing an IPA usage level of 171 FTE. FY 2019 R&RA funding for IPAs is $37.17 million supporting 146 IPA FTE. FY 2019 EHR funding for IPAs is $4.44 million supporting 25 IPA FTE. For both R&RA and EHR, per IPA FTE costs are estimated at a level commensurate with the FY 2017 Actual.

The FY 2019 total IPA compensation is $35.81 million, lost consultant and per diem is $3.17 million, and travel is $2.63 million. Funding for these three categories is associated with full use of NSF's existing IPA FTE allocation and projected IPA costs for FY 2019.

Program Related Administration

Program Related Administration Investments
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Program Related Technology	$76.28	-	$80.80	$4.52	5.9%
Other Program Related Administration	7.63	-	3.65	-3.98	-52.1%
Total, Program Related Administration	**$83.91**	**-**	**$84.45**	**$0.54**	**0.6%**

The FY 2019 Request for Program Related Administration (PRA) is $84.45 million. PRA includes two categories of activities that support NSF's strategic goal, Enhance NSF's performance of its mission,[1] and

[1]NSF (2018). Building the Future: Investing in Discovery and Innovation – NSF Strategic Plan for Fiscal Years (FY) 2018-2022. Retrieved from: www.nsf.gov/about/performance/strategic_plan.jsp

that are directly funded from NSF's program accounts:

- Program Related Technology (PRT); and
- Other Program Related Administration (Other PRA)

Program Related Technology ($80.80 million)

IT investments funded through the R&RA and EHR accounts support NSF's mission activities and is approximately 76 percent of NSF's total IT investment portfolio. These programmatic investments are called Program Related Technology (PRT). NSF's FY 2019 Request for PRT is $80.80 million. The remaining $26.20 million IT investment is funded through the AOAM account and is discussed in the AOAM chapter.

Program Related Technology Investments

(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Mission-Related Applications and Services	$50.29	-	$51.96	$1.68	3.3%
Mission-Related IT Operations and Infrastructure	19.78	-	21.62	1.84	9.3%
Mission-Related Security and Privacy Services	3.98	-	4.98	1.00	25.2%
Mission-Related IT Management	2.24	-	2.24	-	-
Total, Program Related Technology	**$76.28**	**-**	**$80.80**	**$4.52**	**5.9%**

NSF accomplishes its mission by providing federal financial assistance to individuals and institutions whose proposals have been judged the most promising by a rigorous and objective review process. Each stage in the NSF proposal and award management process is supported electronically. The IT services and systems that support the proposal and review process are funded through the PRT investment, an essential element in our Nation's support for science, engineering, and education research.

For FY 2019, NSF's information technology priorities for PRT are to:

- Support the Agency's commitment to "Renewing NSF", specifically focusing on the theme titled "Make IT Work for Us" by investing in several key areas to accelerate necessary technology transformations, while providing a mechanism to transform the agency's workforce to operate in an environment where technology augments and amplifies human performance. A total of $4.0 million will allow NSF to:
  - Accelerate support for modernization of the IT infrastructure and systems that support the business operations of the agency, leveraging cloud offerings to the greatest extent practicable. This will position NSF to continue to operate as an agile organization and will play a major role in enabling NSF's mission, allowing the agency to remain flexible to adapt to business process changes identified from the Renewing NSF initiative.
  - Continue modernization efforts intended to streamline and support efficiencies for managing the lifecycle of proposals, prioritizing key citizen-facing services, while continuing to explore the use of Artificial Intelligence (AI) and machine learning to amplify NSF's ability to meet its mission.
  - Identify, develop, and implement AI-driven tools for the development of NSF staff in an increasingly data intensive and rapidly advancing IT workplace context.
- Enhance the security of NSF's infrastructure to respond to the ever-evolving threat landscape in support of the Cybersecurity Cross-Agency Priority goal: Provide ongoing observation, assessment, analysis, and diagnosis of an organization's cybersecurity: posture, hygiene, and operational readiness.
- Support the continued operation of iTRAK, the Foundation's financial management system, to ensure continued interoperability with NSF's core financial functions during the necessary transition of contract provider.

- Support the Financial Services Support investment, distinct from the iTRAK investment which supports core financials, to modernize NSF's financial management functions thereby increasing transparency and accuracy of reporting between NSF's core financial system (iTRAK) and other mission systems.
- Position the agency's IT portfolio to leverage the Technology Business Management framework for managing IT as a business.

Mission-Related Applications and Services ($51.96 million)
Investments in this category fund the applications and services that support the merit review process, including pre-proposal planning; 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. These investments can be classified as:

- Mission Support Systems, a total of $39.28 million, supports the following activities:
  - $24.41 million provides for the operations and maintenance of NSF's mission support systems, which provide a suite of functionality supporting each stage in the NSF proposal and award management process.
  - $12.87 million for continuous modernization of systems and services that support the merit review process, such as proposal management efficiencies, public access to NSF-funded research, and modernization of the content management system for the citizen-facing NSF.gov website. These modernization efforts are intended to reduce administrative burden on NSF staff and the research community, improving NSF's interactions with and increasing information available to the American public.
  - $2.0 million for "Make IT Work for Us", accelerating integration of AI tools into the renewed merit review process. Specifically, NSF will look to consolidate and integrate functionality intended to reduce the burden on the user with practical applications of cutting-edge technologies such as AI and machine learning. In addition, NSF will leverage AI and machine learning to transform the agency's workforce, in parallel with technology transformations, ensuring the workforce remains relevant and has the necessary skillsets to evolve and meet the agency's future needs.
- NSF's Data Management and Delivery investment, $6.40 million, centralizes and streamlines access to NSF data for agency staff, and provides analytical and visualization capabilities key to data-based decision making. NSF will prioritize efforts to expand access to key datasets and enhance existing analysis capabilities for NSF portfolio management, evaluation, and assessment activities.
- The total FY 2019 investment for iTRAK is $8.26 million. Seventy percent of this request is funded by PRT and 30 percent is funded by AOAM. The PRT portion of the iTRAK request is $5.78 million, to fund operations and maintenance of NSF's core financial system, and to support the necessary transition of the contract provider.

Mission-Related IT Operations and Infrastructure ($21.62 million)
Investments in this category provide funding for operations and maintenance, as well as continuous modernization, of NSF's infrastructure, network, and telecommunications requirements. The FY 2019 Request will allow the agency to accelerate technology transformations essential to making critical infrastructure viable for cloud and shared service offerings, enabling the agency to remain flexible to adapt to increasing demands. Investments include:

- Network ($2.36 million), includes NSF's single network, with wired and Wi-Fi connectivity, for NSF staff and visitors, and virtual meeting support.
- Data Center and Cloud ($6.20 million), includes the resources necessary to support and monitor access to mission applications that enable execution of NSF's mission, and includes $2.0 million in support of the "Make IT Work for Us" initiative to accelerate modernization of the IT infrastructure, improving resilience using cloud offerings, software-defined infrastructure, and automated change management processes.
- End User ($5.09 million), funds NSF's help desk services for internal users (NSF staff) and external

users (the research community including institutions, principal investigators, reviewers, and NSF visitors), which are available 13 hours per day, five days per week.

- Other ($7.97 million) represents costs for off-the-shelf hardware and software, and for delivery services associated with technology transformations. Categorization and reporting of these costs will continue to be refined as future phases of TBM are implemented.

Mission-Related Security and Privacy Services ($4.98 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 investment covers the mission-related portion of NSF's network security, application security, security control testing and tools, automated vulnerability assessment tools, and remediation and intrusion detection services.

The FY 2019 Request will support operations and monitoring support for the Continuous Diagnostics and Monitoring (CDM) tools implemented thus far—including costs for tools and services received in Phases 1 and 2 of the CDM program—and to exploit the full capabilities of CDM offerings, enabling risk-based prioritization of the most significant cybersecurity improvements.

Mission Related IT Management ($2.24 million)
IT Management includes support for the Chief Information Officer and senior IT leadership in the areas of IT strategy and planning, enterprise architecture, capital planning, vendor management, IT budget/finance, and IT strategic communications. In FY 2019, investments in this category will position NSF to take advantage of the technology business management framework, further enhancing the agency's ability to manage IT as a business.

Other Program Related Administration ($3.65 million)

In FY 2019, $3.65 million for NSF's Other PRA includes funding for two Foundation-wide activities:

- NSF support for federal E-Government initiatives that are mission-related; and
- General planning and evaluation activities that are Foundation-wide.

Funding for Other PRA is reduced in FY 2019 as Proposal Management Efficiencies (PME) and Evaluation and Assessment Capabilities (EAC) are moved to line items in the IA budget within the R&RA account. These activities are discussed below in the Other Organizational Excellence Activities section and in the IA narrative within the R&RA chapter.

Other Program Related Administration

(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Proposal Management Efficiencies[1]	$0.32	-	-	-$0.32	-100.0%
Evaluation and Assessment Capabilities[2]	4.71	-	-	-4.71	-100.0%
E-Government Initiatives	1.44	-	1.50	0.06	4.2%
General Planning and Evaluation Activities	1.16	-	2.15	0.99	85.5%
Total, Other Program Related	**$7.63**	**-**	**$3.65**	**-$3.98**	**-52.1%**

[1] For the FY 2019 Request, $920,000 for Proposal Management Efficiencies (PME) is moved from Other Program Related Administration to Planning and Policy Support, a line item in the IA budget within the R&RA account.

[2] In the FY 2018 Request, EAC was moved from Other Program Related Administration to a line item in the IA budget within the R&RA account.

E-Government Initiatives ($1.50 million)

The FY 2019 funding level for NSF program-supported and mission-related E-Government initiatives is consistent with the FY 2019 funding amounts provided by the initiatives' respective managing partners. The $60,000 increase over the FY 2017 Actual reflects FY 2019 funding level changes for the following initiatives:

- The Integrated Award Environment initiative increases approximately $87,000 for Data Rights repayment;
- Grants.gov decreases approximately $30,000 reflecting changes to the Grants.gov funding algorithm used to determine agency contributions; and
- The Human Resources Management Line of Business increases approximately $3,000 reflecting a five percent agency partner contribution increase.

General Planning and Evaluation Activities ($2.15 million)

FY 2019 funding for general planning and evaluation activities supports investments on broad programmatic and policy matters of NSF-wide scope and benefit. This includes activities such as the verification and validation of performance information; IPA FTE in the office of Budget Finance and Award Management and the Office of the Director; and certain costs associated with the American Association for the Advancement of Science fellowships program. Also included is $87,851 for interagency management councils that support cross-agency management reforms and efficiencies and $77,716 for Cross-agency Priority (CAP) Goals. The FY 2019 funding level is based on the level of general planning and evaluation activities and projects that occurred in FY 2017 and anticipated activities for FY 2019.

Other Organizational Excellence Activities

Other Organizational Excellence Activities
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Evaluation and Assessment Capability (EAC)[1]	[$4.71]	-	$3.00	-$1.71	-36.3%
Planning and Policy Support[2]	2.09	-	2.50	0.41	19.4%
Total, Other Organizational Excellence Activities	**$2.09**	**-**	**$5.50**	**$3.41**	**162.7%**

[1] In the FY 2018 Request, EAC was moved from Other Program Related Administration to a line item in the IA budget within the R&RA account. FY 2017 activities were supported by Other Program Related Administration; the FY 2017 Actuals are displayed here for comparability.

[2] For the FY 2019 Request, $920,000 for Proposal Management Efficiencies (PME) is moved from Other Program Related Administration to Planning and Policy Support, a line item in the IA budget within the R&RA account.

Evaluation and Assessment Capability (EAC) ($3.0 million)
EAC is an integral part of NSF's operations. It supports, coordinates, and conducts NSF-wide program evaluations and evidence generation and utilization to catalyze learning and improvement through collaboration with NSF's directorates and offices. More detailed information on EAC can be found within the Integrative Activities narrative in the Research and Related Activities chapter.

Planning and Policy Support ($2.50 million)
Planning and Policy Support is a foundation-wide activity in the Integrative Activities budget that supports select NSF-wide policy and planning activities. More detailed information on Planning and Policy Support can be found within the Integrative Activities narrative in the Research and Related Activities chapter.

AGENCY OPERATIONS AND AWARD MANAGEMENT (AOAM)

$333,630,000
-$48,440,000 / -12.7%

Summary of Agency Operations and Award Management
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Personnel Compensation and Benefits[1]	$220.76	-	$229.71	$8.94	4.1%
Management of Human Capital	10.28	-	10.11	-0.18	-1.7%
Travel	5.53	-	5.45	-0.08	-1.4%
Information Technology	31.32	-	26.20	-5.12	-16.3%
Space Rental	36.34	-	31.19	-5.15	-14.2%
Operating Expenses	17.04	-	17.87	0.83	4.9%
Building and Administrative Services	14.05	-	13.10	-0.95	-6.8%
NSF HQ Relocation	46.74	-	-	-46.74	-100.0%
Total, AOAM	**$382.06**	-	**$333.63**	**-$48.44**	**-12.7%**

[1] Funding levels for PC&B reflect direct appropriated funds only. In FY 2017, $4.19 million in Administrative Cost Recoveries (ACRs) were received bringing the total PC&B obligation to $224.95 million. Approximately $5.48 million in ACRs are expected in FY 2019 to meet the total PC&B requirement of $235.19 million.

Investments in the AOAM account 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 investments support NSF Strategic Goal 3: Enhance NSF's performance of its mission.[1] AOAM's priorities are framed by two strategic objectives:

- Strategic Objective 1: Attract, retain, and empower a talented and diverse workforce; and
- Strategic Objective 2: Continually improve agency operations.

NSF AOAM Workforce

AOAM NSF Workforce
(Full-Time Equivalent (FTE) and Other Staff)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
NSF AOAM FTE Allocation					
NSF AOAM -- Regular	1,310	-	1,310	-	-
NSF AOAM -- Pathways Intern	42	-	42	-	-
Subtotal, FTE Allocation	**1,352**	**-**	**1,352**	**-**	**-**
NSF AOAM FTE Usage					
NSF AOAM -- Regular	1,309	-	1,310	1	0.1%
NSF AOAM -- Pathways Intern	28	-	42	14	48.4%
Subtotal, FTE Usage	**1,337**	**-**	**1,352**	**15**	**1.1%**
Detailees to NSF	3	-	3	-	-
Total, Workforce (Usage)	**1,340**	**-**	**1,355**	**15**	**1.1%**

[1] NSF (2018). Building the Future: Investing in Discovery and Innovation – NSF Strategic Plan for Fiscal Years (FY) 2018-2022. Retrieved from: www.nsf.gov/about/performance/strategic_plan.jsp

NSF's FY 2019 FTE allocation is 1,352. The FY 2019 FTE estimated usage is 1,310 regular and 42 Pathways FTE.

Personnel Compensation and Benefits (PC&B)

Personnel Compensation & Benefits
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Regular FTE Usage (projected)	*1,309*	*-*	*1,310*	*1*	*0.1%*
Student FTE Usage (projected)	*28*	*-*	*42*	*14*	*48.4%*
Regular FTE Base Salary	$168.69	-	$176.74	$8.05	4.8%
Student Salary	1.14	-	1.83	0.69	60.3%
Other Compensation[1]	1.22	-	1.70	0.48	39.7%
Awards	2.36	-	2.10	-0.26	-10.9%
Subtotal, FTE Compensation	**$173.41**	**-**	**$182.37**	**$8.96**	**5.2%**
Benefits	50.45	-	50.89	0.44	0.9%
Other Benefits[2]	1.09	-	1.92	0.83	76.1%
Subtotal, Benefits	**$51.54**	**-**	**$52.81**	**$1.27**	**2.5%**
Total, PC&B	**$224.95**	**-**	**$235.19**	**$10.24**	**4.6%**
Source of Funds					
AOAM Appropriation	$220.76	-	$229.71	$8.94	4.1%
Administrative Cost Recoveries[3]	4.19	-	5.48	1.29	30.9%
Total, Effective BA for PC&B	**$224.95**	**-**	**$235.19**	**$10.24**	**4.6%**

[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] ACR levels for FY 2019 are estimated based on the level in FY 2016.

The FY 2019 Request for Personnel Compensation and Benefits (PC&B) is $235.19 million. Funding for PC&B reflects funding from two sources: $229.71 million in AOAM appropriated funds; and $5.48 million from Administrative Cost Recoveries (ACRs) received during the year.

The PC&B cost estimate will support the projected FY 2019 year-end usage of 1,310 regular full-time equivalent (FTE) employees, a total of 42 Pathways intern FTE, associated cost of benefits, general workforce performance awards (GWFPA), and Senior Executive Service (SES) bonuses. The FY 2019 Request for PC&B also contains $917,000 for the Federal Transit Benefits Program. Amounts necessary to cover required agency costs associated with the OPM data breach will also be funded from within the PC&B total.

Management of Human Capital

Management of Human Capital
(Dollars in Millions)

FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Percent
$10.28	-	$10.11	-$0.18	-1.7%

The FY 2019 Request funding for Management of Human Capital is $10.11 million. This level of funding will enable NSF to maintain operational support activities, training and development programs essential for NSF's permanent and rotator staff, and contractual support for human capital initiatives. The FY 2019 Request level will support:

- 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 incentive and other awards. FY 2019 Request funding is $3.28 million.
- NSF's HR systems accessed through shared service providers, such as the Federal Personnel Payroll System, the time and attendance system (WebTA), and eRecruit capabilities using USAJobs, and providing support for personnel security and suitability investigations for incoming staff. FY 2019 Request funding is $1.43 million.
- Strategic human capital support contracts. NSF relies on strategic human capital support contracts for assistance in developing new approaches to critical human resource needs including those identified and highlighted in NSF's Strategic Review process, Strategic Goal 3: Enhance NSF's performance of its mission, Strategic Objective 1: Attract retain, and empower a talented and diverse workforce. FY 2019 Request funding is $1.83 million.
- 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. These training and development activities are designed to help ensure that the workforce, including permanent and rotating staff, as well as new supervisors and executives, are equipped with the tools needed. FY 2019 Request funding is $2.51 million.
- Workplace and work-life support for employees through NSF's health and family-friendly activities, including the health unit, employee assistance program and child care subsidy. FY 2019 Request funding is $915,000.
- Outreach, career fairs, and other program support including activities such as the Federal Employees Viewpoint Survey. FY 2019 Request funding is $150,000.

NSF Employee Travel

NSF Employee FTE Travel
(Dollars in Millions)

FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Percent
$5.53	-	$5.45	-$0.08	-1.4%

The FY 2019 Request for NSF employee FTE travel is $5.45 million. NSF employee FTE travel is based on the travel activity associated with utilization of 1,310 regular FTE. It includes travel-related funding for site reviews, outreach activities, and post-award monitoring and oversight related to the projected level of program activities contained in the FY 2019 Request. Travel costs for IPA FTE are discussed in the

Program Accounts: RRA and EHR narrative. A summary of total NSF travel is presented in the Organizational Excellence Overview.

Information Technology

NSF funds administrative information technology (IT) applications from the AOAM account while mission-related 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: R&RA and EHR chapter. A summary of total NSF IT is presented in the Organizational Excellence Overview.

Administrative applications services and support; associated IT operations and infrastructure; security and privacy services; and related IT management services funded by the AOAM account are discussed below.

AOAM Information Technology
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Administrative Applications Services and Support	$6.64	-	$7.10	$0.46	6.9%
Administrative IT Operations and Infrastructure	21.13	-	15.26	-5.87	-27.8%
Administrative Security and Privacy Services	3.03	-	3.33	0.30	9.8%
Administrative IT Management	0.51	-	0.51	-	-
Total, AOAM IT	**$31.32**	-	**$26.20**	**-$5.12**	**-16.3%**

Information technology investments 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 2019, NSF's information technology priorities for AOAM include:

- Continuing support for modernization of the IT infrastructure and systems that support the administrative operations of the agency, leveraging cloud offerings to the greatest extent practicable. This will position NSF to continue to operate as an agile organization and will play a major role in enabling NSF's mission and allowing NSF to remain flexible to adapt to "Renewing NSF" areas.
- Enhancing the security of NSF's infrastructure to respond to the ever-evolving threat landscape in support of the Cybersecurity Cross-Agency Priority goal: Provide ongoing observation, assessment, analysis, and diagnosis of an organization's cybersecurity: posture, hygiene, and operational readiness.
- Supporting the continued operation of iTRAK, the Foundation's financial management system, ensuring continued interoperability with NSF's core financial functions during its transition of contract provider.
- Supporting the Financial Services Support investment to provide continuation for end-to-end electronic support for the full suite of NSF's financial management functions. This is distinct from the iTRAK investment which supports core financials.
- Positioning the agency's IT portfolio to leverage the Technology Business Management (TBM) framework for managing IT as a business.

Administrative Applications Services and Support ($7.10 million)
Investments in this category support administrative applications, such as the NSF website, NSF's human resources management systems, and iTRAK.

- iTRAK is NSF's financial management system. In FY 2019, the total request for iTRAK is $8.26 million. Seventy percent of this request will be funded by the R&RA and EHR accounts and 30 percent will be funded by the AOAM account. The AOAM portion of the FY 2019 Request for iTRAK is $2.48 million and will fund operations and maintenance of the core financial system.
- A total of $500,000 will fund the financial services support investment, an investment intended to provide end-to-end electronic support for the full suite of NSF's financial management functions.
- Other administrative applications services funding is $2.97 million and will provide for operations and necessary technology refreshes for administrative and collaboration tools, such as SharePoint.
- A total of $1.15 million will be used for ongoing operations and maintenance of the systems that support the strategic management of NSF human capital, including those that enable the effective recruitment, retention, development, and use of NSF staff and that align with NSF's Strategic Goal 3: Enhance NSF's performance of its mission, Strategic Objective 1: Attract, retain, and empower a talented and diverse workforce.

Administrative IT Operations and Infrastructure ($15.26 million)

Investments in this category provide funding for operations and maintenance, as well as continuous modernization, of ongoing activities that support administrative applications. Specifically, the investments in this category are classified as:

- Network ($1.88 million), providing access to administrative applications and services via a single network with wired and Wi-Fi connectivity, for NSF staff and visitors, and for virtual meeting support. This investment also includes voice services via NSF's modernized VoIP solution.
- Data Center and Cloud ($3.34 million), leveraging cloud offerings to continue reducing the footprint of NSF's single on site data center, while enabling reliability and flexibility for future expansion.
- End User ($4.05 million), providing help desk services and customer care support for internal users (NSF staff) during NSF business hours.
- Other ($6.0 million) represents costs for off-the-shelf hardware and software, and for delivery services associated with technology transformations. Categorization and reporting of these costs will continue to be refined as future phases of TBM are implemented.

Administrative Security and Privacy Services ($3.33 million)

Investments in this category include the portion of NSF's IT Security program related to administrative applications, which provides for security and compliance oversight for NSF's IT portfolio. The investment includes: offerings from the Continuous Diagnostics and Mitigation (CDM) program; automated configuration management tools that manage security patches and provide proactive protection from viruses, spyware, and other threats; application security; security control testing and tools; automated vulnerability assessment tools; and remediation and intrusion detection services.

Administrative IT Management ($510,000)

IT Management includes support for the Chief Information Officer and senior IT leadership in the areas of IT strategy and planning, enterprise architecture, capital planning, vendor management, IT budget/finance, and IT strategic communications. In FY 2019, investments in this category will position NSF to take advantage of the Technology Business Management framework, further enhancing the agency's ability to manage IT as a business.

Space Rental

Space Rental
(Dollars in Millions)

FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
$36.34	-	$31.19	-$5.15	-14.2%

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. In addition, rent paid for the parking structure to the owner of the new headquarters building in Alexandria is included.

In FY 2019, NSF will occupy over 700,000 square feet of space, primarily in one leased office building located in Alexandria, Virginia. The FY 2019 Request for Space Rental is $31.19 million, a decrease of $5.15 million, 14.2 percent, below the FY 2017 Actual, primarily driven by lower rent costs at the Alexandria headquarters.

Operating Expenses

Operating Expenses
(Dollars in Millions)

FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
$17.04	-	$17.87	$0.83	4.9%

The FY 2019 Request for Operating Expenses is $17.87 million. 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 key activities funded by NSF's FY 2019 Request are described below.

- A total of $8.01 million 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 regular FTE usage of 1,310 projected for FY 2019.
- A total of $2.40 million supports large facility business systems reviews, contract close-out, and NSF outreach activities and materials including logistical support for the annual Large Facilities Workshop.
- $1.75 million supports NSF's annual risk assessment, post-award monitoring desk reviews, and post-award adjustment reviews.
- $1.75 million provides financial management support, including financial statement reporting, NSF property reporting, audit deficiencies resolution assistance, and reporting associated with the financial system.
- $780,000 supports NSF's internal control quality assurance activities: documenting, testing, and assessing internal control effectiveness, including effectiveness and efficiency of operations, reliability of financial reporting, and compliance with applicable laws and regulations.
- $470,000 for the purchase of a contract writing system that will be integrated with the financial system (iTRAK), migration of data from old to new system, and training of users on new system. In addition, this includes licensing, subscription, and infrastructure support for the new E-procurement system.

- $390,000 supports administrative grants processing duties including, processing funding actions, reviewing payment requests, and answering inquiries. In addition, funding is included for verifying Davis-Bacon Act reports.
- $360,000 supports NSF's Enterprise Information System and the Budget Internet Information System to provide accurate, consistent information on financial data, funding rate, award size, and other statistics to NSF staff and the public. FY 2019 funding ensures that the system and related data analysis will continue to respond to evolving information needs.
- $340,000 provides support for a review of grantee expenditures for unallowable costs, NSF's grant accrual, and the Award Cash Management Service. The results of these analyses are used to support NSF's post-award monitoring programs.
- A total 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. Activities supported assist with maintaining NSF's model Equal Employment Opportunity status; not providing accommodations could be viewed as discrimination according to Sections 501 and 505 of the Rehabilitation Act of 1973.
- A total of $220,000 provides funding for the congressionally-mandated Committee on Equal Opportunities in Science and Engineering (CEOSE) activity. This request covers contractor services and meeting support for the CEOSE. CEOSE is an NSF advisory committee that provides advice on policies and programs to broaden participation of women, minorities, and persons with disabilities.
- $153,000 for the negotiation and issuance of indirect cost rates for a number of organizations for which NSF is the cognizant agency.
- $181,000 provides on-site, project management support to plan, coordinate, and execute NSF activities in connection with the Digital Accountability and Transparency Act responsibilities and operations.
- $107,000 provides support for the Integrated Acquisition Environment, an e-government initiative managed by the General Services Administration; a contracting information online knowledge management resource; the printing and mailing of 1099 forms, a monthly download to update routing numbers in NSF's financial system (iTRAK); and financial assistance award audit services to support incurred cost audits, accounting system audits, estimating system audits, and special projects which will provide NSF with information that will assist in the negotiation, award, administration, repricing, and settlement of large facilities financial assistance awards.
- $90,000 provides purchase card program oversight support.

Building and Administrative Services

Building and Administrative Services
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Information Dissemination	$3.56	-	$2.72	-$0.84	-23.7%
Workplace Management	5.40	-	4.97	-0.44	-8.1%
Panel Support, Meeting Management, and Proposal Services	5.09	-	5.42	0.33	6.5%
Total, Building & Admin Services	**$14.05**	-	**$13.10**	**-$0.95**	**-6.8%**

The FY 2019 Request level for building and administrative services is $13.10 million. This investment supports three sets of activities: information dissemination; workplace management; and panel support, meeting management, and proposal services.

Information Dissemination ($2.72 million)
The total investment of $2.72 million for FY 2019 supports the following activities:

- NSF's website and intranet operations and maintenance, as well as graphic and user interface design;
- 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;
- Website and business application development and user experience support;
- Graphic design and commercial printing;
- Regulatory reporting, processing and production; and
- Records management, and the establishment and execution of records management policies and procedures.

Workplace Management ($4.97 million)
The total FY 2019 Request for 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, physical security, and access control;
- Space management and facility operations, including development of space plans and assignments, space reconfigurations, and facility service and maintenance; and
- Activities related to property—the oversight and planning of mailroom shipping and receiving operations, property receipt, inventory, and tracking.

Panel Support, Meeting Management, and Proposal Services ($5.42 million)
FY 2019 investments in this category support all stages of NSF's merit review process (including pre-review, during, and post-review customer support). Funding also is provided for

- 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;
- Management and support of all agency printing devices; and
- Library and research assistance.

NSF Headquarters Relocation

NSF Headquarters Relocation
(Dollars in Millions)

FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
$46.74	-	-	-$46.74	-100.0%

NSF completed the move of its headquarters to the new building in Alexandria, VA in September 2017. No funding is requested for this activity in FY 2019.

AOAM by Object Class

AOAM by Object Class
(Dollars in Thousands)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Personnel Compensation	$169,224	-	$176,894	$7,670	4.5%
Personnel Benefits	51,405	-	52,811	1,406	2.7%
Travel and Transportation of Persons	5,513	-	5,450	-63	-1.1%
Transportation of Things	296	-	244	-52	-17.6%
Rental Payments to GSA	32,092	-	31,194	-898	-2.8%
Rent to Others	187	-	153	-34	-18.1%
Communications, Utilities and Misc. Charges	2,263	-	1,952	-311	-13.8%
Printing and Reproduction	699	-	644	-55	-7.9%
Advisory and Assistance Services	79,403	-	42,151	-37,252	-46.9%
Other Services	11,165	-	9,158	-2,007	-18.0%
Purchases of Goods & Srvcs from Gov't. Accts	24,253	-	8,589	-15,665	-64.6%
Operations and Maintenance of Facilities	-	-	-	-	N/A
Operations and Maintenance of Equipment	319	-	261	-58	-18.3%
Supplies and Materials	1,703	-	1,355	-348	-20.5%
Equipment	3,541	-	2,775	-766	-21.6%
Land and Structures	-	-	-	-	N/A
Total, AOAM	**$382,063**	**-**	**$333,630**	**-$48,433**	**-12.7%**

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.

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 Alexandria, Virginia.

Rental Payments to Others: This category includes rent paid for the parking structure to the owner of the new headquarters building in Alexandria.

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; and support for OMB Circular A-123 reviews.

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.

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; ~~$328,510,000:~~*$333,630,000: 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 ~~2018~~*2019* 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 $5,000,000 shall remain available until expended.~~

Note.—A full-year 2018 appropriation for this account was not enacted at the time the budget was prepared; therefore, the budget assumes this account is operating under the Continuing Appropriations Act, 2018 (Division D of P.L. 115–56, as amended). The amounts included for 2018 reflect the annualized level provided by the continuing resolution.

Agency Operations and Award Management
FY 2019 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 2017 Appropriation	$330.00	$23.71	-$0.41	-$0.33	$29.09	$382.06
FY 2018 Annnualized CR	327.76	0.41				328.17
FY 2019 Request	333.63					333.63
$ Change from FY 2018 Annualized CR						$5.46
% Change from FY 2018 Annualized CR						1.7%

Explanation of Carryover

Within the Agency Operations and Award Management (AOAM) no-year component, $414,302 was carried over into FY 2018.

NSF Headquarters Relocation
- Amount: $414,302
- Reason: Resources reserved for unanticipated expenses related to the new NSF Headquarters.
- Obligation: Anticipated FY 2018 Quarter 2

NATIONAL SCIENCE BOARD (NSB) **$4,320,000**
+$50,000 / 1.2%

The FY 2019 Budget Request for the National Science Board (NSB, Board) is $4.32 million, which is an increase of $50,000 from the FY 2017 Actual of $4.27 million. This FY 2019 Budget Request will enable the Board to fulfill its policymaking and oversight responsibilities for NSF. It will also allow the Board to continue its statutory responsibilities as outlined in the Organic Act, including activities related to the authorization of major research facilities projects.

National Science Board Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 Annualized CR	FY 2019 Request	Change Over FY 2017 Actual Amount	Change Over FY 2017 Actual Percent
Total, NSB	**$4.27**	**$4.34**	**$4.32**	**$0.05**	**1.2%**
Full-Time Equivalents (FTEs)	18	19	19	1	5.6%

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~~*$4,320,000*: *Provided*, That not to exceed $2,500 shall be available for official reception and representation expenses.

National Science Board
FY 2019 Summary Statement
(Dollars in Millions)

	Enacted/ Request	Expired	Obligations Actual/ Estimates
FY 2017 Appropriation	$4.37	-$0.10	$4.27
FY 2018 Annualized CR	4.34		4.34
FY 2019 Request	4.32		4.32
$ Change from FY 2018 Annualized CR			-$0.02
% Change from FY 2018 Annualized CR			-0.5%

National Science Board in Context

The NSB, established by the NSF Act of 1950, has dual responsibilities to: provide national science policy advice to the President and Congress; and establish policies for NSF within the framework of applicable national policies as set forth by the President and the Congress. 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) research and education community, the Board serves collectively as an advisory body on S&E issues critical to the Nation. Board members serve six-year terms on staggered appointments and are drawn from industry, academe, non-profit organizations, government, and professional scientific societies representing the breadth of S&E disciplines. They are selected to represent all areas of the Nation

based on their eminence in research, education, or public service.

The Board currently convenes at least four formally scheduled public meetings per year, with additional meetings as needed, to review and approve major NSF awards; provide guidance on new programs; oversee and provide policy direction to NSF; oversee the lifecycle of large facilities; and address significant S&E related national policy issues. The Board initiates and conducts studies and reports on a range of policy topics. The Board reviews NSF's priorities to ensure progress and consistency along the strategic direction set for NSF and to ensure balance among new investments and core programs.

Policy Responsibilities

The Board examines issues of importance to the S&E research and education communities, in general, and to NSF, in particular. Topics for exploration are determined through requests from Congress or the President, and as the Board identifies in consultation with the community and NSF management. Recent reports have examined topics such as higher education as a public and private good and the Science, Technology, Engineering, and Mathematics (STEM) workforce.

The Board has several standing committees to assist with its responsibilities. To enable the Board to fulfill its statutory and governance roles more effectively, members approved these new committees and charges in February 2017:

Executive Committee – This statutory Committee includes the Director of NSF, who chairs the Committee, and four elected members from the Board. The Board has delegated to this Committee its authority to approve awards in the rare instances when immediate action is required between Board meetings.

Committee on Oversight – Conducts independent oversight of NSF's operations, processes for risk management, audit plans and results, and processes for complying with laws and regulations; reviews Office of the Inspector General activities and NSF management responses; monitors audits and makes related recommendations to the Board; and oversees the Board's compliance with the Sunshine Act.

Committee on Strategy – Provides a forum for developing the Board's strategic discussions of NSF's budget, programs, organization structure and agency vision; makes recommendations to the Board on annual Budget Requests and quadrennial Strategic Plans; and provides strategic guidance to the Board on NSF's programs.

Committee on National S&E Policy – Oversees development and production of the congressionally-mandated *Science and Engineering Indicators* (*Indicators*) report in collaboration with NSF's National Center for Science and Engineering Statistics (NCSES); helps ensure that the S&E information and policy resources developed by the NSB are high-quality, policy-relevant, and accessible in order to meet stakeholder needs; and helps fulfill the NSB's charge to provide ongoing information and policy advice to Congress and the President on S&E research, education, and workforce issues.

Committee on Awards and Facilities – Addresses strategic issues and recommends policies to the Board related to awards and Major Research Equipment and Facilities Construction projects; makes recommendations to the Board on awards and facilities; and provides lifecycle oversight on facilities and oversight on awards.

Committee on External Engagement – Leads the NSB's communication and engagement efforts with government, industry, the public and the research and education communities, and helps the Board advance the pursuit of national policies for the promotion of research and education in science and engineering.

Subcommittee on Honorary Awards – Reviews nominations for two awards established by the Board: the Vannevar Bush Award and the Public Service Award.

Ongoing activities of the Board include review and approval of the following:

- Large awards, MREFC projects 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
- Transmittal of the NSF Budget Submission to OMB.

The Board also reviews and makes recommendations on the following from NSF:

- Financial management reports for NSF;
- The operation of NSF's merit review system; and
- NSF's research infrastructure portfolio.

Office of the National Science Board

Personnel Compensation and Benefits and Other Operating Expenses

(Dollars in Thousands)

	FY 2017 Actual	FY 2018 Annualized CR	FY 2019 Request	Change Over FY 2017 Actual Amount	Change Over FY 2017 Actual Percent
Personnel Compensation Benefits (PC&B)[1]	$3,070	-	$3,129	$59	1.9%
Staff Development and Training	26	-	38	12	46.2%
Advisory and Assistance Services	812	-	722	-90	-11.1%
Travel and Transportation of Persons	226	-	308	82	36.3%
Communications, Supplies, and Equipment	133	-	120	-13	-9.8%
Representation Costs	3	-	3	-	-
Total, NSB	**$4,270**	**$4,340**	**$4,320**	**$50**	**1.2%**
Full-Time Equivalent	18	19	19	1	5.6%

[1] FY 2019 PC&B includes base salary costs and anticipated within grade and promotion increases.

Personnel Compensation and Benefits

The Board's FY 2019 budget supports a core of full-time policy, communications, administrative, legal, and executive secretariat staff. In addition to providing institutional memory for the Board, the Board Office staff provides both the resources and expertise for coordinating and conducting science and education policy analyses and development and implementing broad communication and outreach programs. Staff also advise the Board on legal aspects of its policies and activities and provides operational and administrative support that are essential for the Board to fulfill its mission.

Other Operating Expenses

The Board's Advisory and Assistance Services budget line includes some of the resources needed to produce policy reports such as *Indicators*. Over the past several years, the Board has heightened its efforts to increase the accessibility of *Indicators* and to facilitate the use of *Indicators* data in policy decisions and analysis through the creation of interactive digital products. (The next edition of *Indicators* is scheduled for delivery to Congress in January 2018.) In addition, some of the Board's reports require expert support from

organizations such as the Science and Technology Policy Institute, a federally-funded research and development center supported by NSF.

Other items in the Advisory and Assistance Services line support NSB document management, including maintenance of an electronic official records management system, which enables compliance with federal records requirements; the efficient search, identification, and retrieval of relevant documents for reference and research purposes; the webcasting and archiving of all open Board meetings and transcription services; and a board management software, which facilitates effective and efficient NSB meetings.

NSB's Travel and Transportation of Persons budget line primarily covers Board member travel costs to NSF headquarters for the Board's four annual meetings and a member-only retreat, travel for invited speakers and participants in Board activities, and community engagement activities organized by the Board, such as listening sessions designed to improve responsiveness to the concerns and priorities of the S&E community. Most recently, the Board organized listening sessions in Louisiana to explore the challenges and opportunities with the Skilled Technical Workforce and with Women and Underrepresented Minorities in STEM. Past NSB listening sessions have led to significant policy recommendations, such as those included in the Board's Reducing Investigators' Administrative Workload for Federally Funded Research report. Also supported in this budget line is Board member travel to site visits in support of NSB's oversight of NSF's large programs and facilities. The Communications, Supplies, and Equipment budget line funds the range of electronic purchases, upgrades and installations of equipment such as computers.

The FY 2019 Budget Request will facilitate the continued thoughtful enhancement of the Board's efforts to strengthen the U.S. S&E enterprise through its policy and information-related activities. Specifically, the Request will support the NSB's continued engagement with stakeholders—including Congress, the Administration, academia, the business community, and the general public—to better understand their diverse needs. In turn, this will help the NSB (and NCSES) improve the usefulness of the resources it produces, ensuring that these stakeholders continue to have access to timely, comprehensible, and objective S&E data and policy guidance.

OFFICE OF INSPECTOR GENERAL (OIG) **$15,345,000**
+$248,000 / 1.6%

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 2019 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 2019 Budget Request for OIG is $15.35 million, an increase of $248,000 from the FY 2017 Actual of $15.10 million.

Office of Inspector General Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 Annualized CR	FY 2019 Request	Change Over FY 2017 Actual Amount	Change Over FY 2017 Actual Percent
Total, OIG	**$15.10**	**$15.10**	**$15.35**	**$0.25**	**1.6%**
Full-Time Equivalents (FTEs)	72	69	71	-1	-1.4%

Appropriations Language

For necessary expenses of the Office of Inspector General as authorized by the Inspector General Act of 1978, ~~$15,008,000~~*$15,345,000*, of which $400,000 shall remain available until September 30, ~~2019~~*2020*.

Office of Inspector General
FY 2019 Summary Statement
(Dollars in Millions)

	Enacted/ Request	Unobligated Balance Available Start of Year	Unobligated Balance Available End of Year	Adjustments to Prior Year Accounts	Obligations Actual/ Estimates
FY 2017 Appropriation	$15.20	$0.38	-$0.39	-$0.09	$15.10
FY 2018 Annualized CR	15.10	0.39			15.49
FY 2019 Request	15.35				15.35
$ Change from FY 2018 Annualized CR					-$0.15
% Change from FY 2018 Annualized CR					-0.9%

Explanation of Carryover

Within the Office of Inspector General (OIG) two-year account, $392,372 was carried over into FY 2018.

Office of the Inspector General
- Amount: $392,372
- Reason: Funds are expected to be used to procure financial and forensic audit services. 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.
- Obligation: Anticipated FY 2018 Quarter 4

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 of civil and criminal wrongdoing related to NSF programs and operations, including all entities and individuals that receive NSF funds;
- Evaluate allegations of research misconduct, such as fabrication, falsification, or plagiarism, related to NSF-funded research;
- 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;
- Keep both agency management and Congress fully and currently informed about problems, recommended corrective actions, and progress being made in improving the management and conduct of NSF programs, to include the issuance of a Semiannual Report to Congress.

OIG performs audits of grants, contracts, and cooperative agreements funded by NSF's programs; and 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. OIG 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. Audit work mandated by the Federal Information Security Modernization Act of 2014 (FISMA), the Improper Payments Elimination and Recovery Act (IPERA), and the Digital Accountability and Transparency Act (DATA Act) is also performed annually.

OIG also audits the systems used by NSF to prepare the financial statements. In addition, 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 is vested with law enforcement authority and 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 perform work for NSF. Allegations of research misconduct by NSF recipients are also investigated. 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 some cases to NSF for administrative resolution and when indicated will recommend modifications to agency policies and procedures to ensure the integrity of NSF's business systems. OIG 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, criminal investigators, management 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, the 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 audit of the agency's financial statements and annual review of its compliance with the Federal Information Security Modernization Act of 2014 (FISMA).

Office of Inspector General
Personnel Compensation and Benefits and General Operating Expenses
(Dollars in Thousands)

	FY 2017 Actual	FY 2018 Annualized CR	FY 2019 Request	Change Over FY 2017 Actual Amount	Change Over FY 2017 Actual Percent
Personnel Compensation and Benefits[1]	$12,360	-	$12,162	-$198	-1.6%
Travel & Transportation of Persons	224	-	185	-39	-17.4%
Advisory & Assistance Services[2]	1,799	-	2,548	749	41.6%
Rent	83	-	100	17	20.5%
Information Technology	89	-	50	-39	-43.8%
Communications, Supplies, Equipment & Other Services	542	-	300	-242	-44.6%
Training	*192*	-	*150*	-42	-21.9%
Other	*350*	-	*150*	-200	-57.1%
Total, OIG	**$15,097**	**$15,096**	**$15,345**	**$248**	**1.6%**
Full-Time Equivalents	72	69	71	-1	-1.4%

[1] FY 2019 PC&B includes base salary costs and anticipated within grade and promotion increases.

[2] Includes the costs of the annual financial statements audit and the outsourcing of contracting services.

An FY 2019 appropriation of $15.35 million will enable OIG to carry out the core elements of its mission with a workforce of 71 FTEs. OIG's appropriation is just 0.2 percent of NSF's, and serves as a safeguard against waste, fraud, and abuse within the agency's 42,000 active awards worth more than $28.0 billion.

Between FY 2013 and FY 2017, OIG has sustained an increase in its average cost per FTE of 19.4 percent, as personnel costs and benefits have increased more than expected, and professionals such as lawyers, investigators and CPAs have replaced administrative staff. The office strives to maintain a workforce of at least 68-71 FTEs to carry out our most critical responsibilities. As our current workforce ages, new hires are critical to revitalizing our workforce and are carefully vetted for technical skills along with their potential to assume more senior management responsibilities as they progress. Currently, approximately 24 percent of our staff (mostly managers) are eligible to retire.

Beyond its annual payment of dues, OIG has made outsized contributions to the Inspector General community and the government at large through its leadership in the Council of the Inspectors General on Integrity and Efficiency (CIGIE). The NSF Inspector General has served as the CIGIE Vice Chair since 2014, and as such helped lead the community as it supported the passage of the Inspector General Empowerment Act. NSF OIG has also played a leading role in founding and running two working groups aimed at raising awareness within the IG community about: preventing fraud within the SBIR/STTR programs; and using government-wide suspension and debarment as tools to deter and reduce instances of fraud, waste and abuse. In addition, NSF OIG led a working group with representatives from OIGs at over 20 grant-making agencies that provided valuable feedback to OMB as it worked to combine eight grant-related circulars into the Uniform Guidance.

Economy and Efficiency of Operations. For context, in operating a lean, efficient organization, the NSF Office of Inspector General practices the principles it espouses in its reports. In recent years OIG has

reduced its senior leadership team from five to four, and devolved senior level administrative responsibilities to lower graded staff, saving $220,000 per year. The Assistant Inspector General for Investigations doubles as Chief Information Officer, saving yet another FTE. In addition, OIG streamlined its administrative unit, electing to re-allocate as many FTEs as possible to line staff that directly perform audits and investigations.

Funding for "upstream" preventive activities, such as educating researchers about rules and requirements associated with federal grants, is reduced from previous years in order to ensure that adequate resources are available for more urgent audits and investigations that will have greater effect. Investments in equipment and technology upgrades (e.g., expansion of our data analytics capability for Audits and Investigations) are pursued only if a persuasive business case can be made.

The Office of Audits (OA) and Office of Investigations (OI) have each recently reorganized themselves to better align their activities with their mission. For example, OA recently reduced the number of audit divisions from five to three, while OI streamlined the intake and handling of Hotline calls to respond more rapidly to information from whistleblowers and others. Both offices recently invested in new systems that automate many of the steps involved in the production and recordkeeping of their reviews and cases. This has significantly reduced the number of support staff and storage space (for paper records) needed in each office. They have also revised their respective operations manuals to implement work processes that improve efficiency and reduce errors in OIG final products.

Other cost saving measures include:

- Outsourced OIG contracting services to the Department of Interior in order to maintain independence from the agency in the contracting arena (an area subject to oversight). Outsourcing this function was more cost effective than hiring a contracting officer.
- Eliminated two student positions that saved $80,000.
- Reorganized front office to increase the IG's capacity to focus on higher level strategic matters.
- Office of Counsel conducts thorough reviews of all reports and contracts to identify potential legal issues at the earliest possible time and prevent costly re-work and unintended consequences.
- Manage and track required professional training on-line through the use of a third party provider to reduce the cost of obtaining Continuing Professional Education credits.
- Expanded use of SharePoint collaborative platform to provide staff with one virtual location for most OIG information, and enable them to work more efficiently.
- Utilized high speed scanners to upload paper evidence thereby reducing time spent copying, handling, and storing voluminous files.
- Increased reliance on WebEx and other teleconferencing technologies to reduce travel costs.

OIG's bottom line results demonstrate its effectiveness. In just the past two fiscal years, OA has issued 78 audit reports with over $16.0 million in questioned costs. During the same period, OI secured $16.60 million in investigative recoveries.

Office of Audits (OA). The Office of Audit conducts audits and reviews of NSF's finances and operations that are either mandated by statute or discretionary. Audit work required by statute has grown in recent years from auditing NSF's financial statements and compliance with the Federal Information Security Modernization Act of 2014 (FISMA), to reviewing compliance with new legislation, such as the Improper Payments Elimination and Recovery Act (IPERA), and the Digital Accountability and Transparency Act (DATA Act). The universe of potential topics for discretionary audits is large, consisting of about 42,000 active awards worth $28.0 billion and all of NSF's internal programs and operations. Historically, the OA audit plan includes about 40 discretionary audits.

Much of our recent discretionary audit work has focused on NSF's construction and management of its large facilities. Since 2010, OIG has issued 59 reports containing more than 149 recommendations to improve NSF's use and management of cooperative agreements for the construction and operation of its high-dollar, high-risk research facilities. As a direct result of these reports, NSF has adopted new policies and procedures to strengthen its monitoring of large facilities. NSF frequently funds the development of large-scale, multiuser scientific facilities through federal assistance awards under cooperative agreements. As of July 2017, NSF supports a broad array of 23 major research facilities, which individually cost between $100.0 million and $500.0 million each to construct.

As of January 2017, NSF had 459 active cooperative agreements totaling nearly $8.0 billion. Twenty-two of these agreements are valued at over $50.0 million each and add up cumulatively to more than $4.40 billion over the lifecycle of the facilities. This audit work will help strengthen the Foundation's ability to ensure grant and procurement funds are not wasted by improper expenditures and mismanagement. Strong controls, as well as increased oversight by additional OIG staff, will help ensure NSF obtains critical assets and services necessary to meet its missions in a declining budget environment.

For example, construction is ongoing for the $469.0 million National Ecological Observatory Network (NEON), a continental-scale observation system for examining ecological change over time. Beginning in 2011, auditors identified serious flaws in NEON's proposed construction budget and issued three inadequacy memos along with an adverse opinion on the proposed budget. Within the proposal, OIG found $154.0 million in questioned and unsupported costs (approximately 36 percent of the total budget). Our concerns about NEON's finances were validated in June 2015 when NEON management informed NSF that the project was facing a potential cost overrun of $80.0 million. Similar issues surfaced during OIG's review of proposed costs for the $467.70 million Large Synoptic Survey Telescope (LSST).

NSF generally spends significantly more on operating its facilities than it does on constructing them. NSF requested over $193.0 million for fiscal year 2017 to pay for four large facility construction projects. In contrast, NSF's operation and maintenance request for its existing large facilities for the same period was over $1.0 billion. We have recently initiated a review that focuses on the risk of commingling construction and operations funds. Ensuring that strong controls exist over the use of such funds is vital, as use of operations funds for construction work can hide cost overruns and deplete funding needed for the operations phase. OIG will also monitor the actions NSF takes in response to requirements in the American Innovation and Competitiveness Act, which mandates several important controls to be applied in the development of NSF's large facilities projects.

OIG audits have also led NSF to pay more attention to the amounts it pays scientists, engineers, and educators who come to NSF under Intergovernmental Personnel Act (IPA) assignments. Individuals on IPA appointments remain employees of their home institutions. Thus, pay and benefits for IPAs are set by their home institutions and are not subject to limitations on federal pay and benefits.

Additionally, in FY 2018 and beyond OIG will monitor the design, construction, and ongoing capital investment and support of NSF's major initiative known as the Antarctic Infrastructure Modernization for Science, or AIMS. According to NSF, the AIMS project will ensure that McMurdo Station remains a viable platform for supporting Antarctic science for the next 35 to 50 years. This new major initiative, as well as ongoing support for the U.S. Antarctic Program, will be accomplished through a series of large contracts.

Office of Investigations (OI). The NSF Office of Investigations was vested with law enforcement authority by the Department of Justice in 2012. OI's staff of 21 line investigators are divided into three units and cover the entire spectrum of investigative functions. The Research Integrity/Admin Investigations (RIA) division is primarily responsible for investigating allegations of Research Misconduct (RM) and personnel misconduct within NSF. Staff from this unit also serve as our principal liaison to the research community,

through the conduct of organized outreach events, consultations on referred RM investigations, and participation in professional scientific associations and interagency RM working groups.

Our Program Integrity (PI) division is primarily responsible for investigating allegations of civil and criminal wrongdoing. They also serve as our principal liaison to the federal OIG and law enforcement communities, as well as to federal and state prosecuting authorities. They perform this liaison through leadership of, and participation in, numerous formal and informal working groups and through direct outreach to particular elements of those communities.

The Investigative Legal (IL) division works with both RIA and PI in the successful accomplishment of investigations, liaison activities, and outreach to both the government and science communities. IL is also responsible for liaison with formal and informal federal working groups assembled to craft, refine, and educate the IG community on the tools available to identify, deter, and remedy fraud against the government. Such working groups have focused on the Program Fraud Civil Remedies Act and Suspension & Debarment (a mechanism that prevents irresponsible parties from receiving federal funds).

The work of OIG's Office of Investigations serves as an important deterrent to grant fraud and research misconduct. OI consistently contributes much more than its cost to the government's bottom line. Between FY 2009 and FY 2016, OI recovered almost $35.0 million for the government. In FY 2016 alone, our 21 line investigators recovered $8,926,748, an average of $441,966 per investigator, approximately three times their average salaries.

OI's workload has increased in recent years due primarily to growth in Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) cases. Our proactive efforts generated over 175 SBIR/STTR-related cases, while the number of awards has increased from 599 to 715 (an increase of almost 20 percent) over three years. Addressing OIG's "prevent" mission, OI has successfully partnered with NSF program managers to improve the processes and procedures surrounding the SBIR/STTR program in a manner that greatly reduces the opportunity to fraudulently abuse these important programs. Through its leadership of the SBIR Working Group, OI has also shared those opportunities for process and policy improvements with other OIGs at SBIR-award making agencies.

Despite its relatively small size, OI's activities consistently benefit the federal government far beyond NSF. The Assistant IG for Investigations (AIGI) has been Chair of the CIGIE AIGI Committee for the past two years. In that role, he plans and presides over quarterly meetings that gather AIGIs and IGs from all 73 agency OIGs. In addition, OI's staff have produced, and annually updates, a digest of successfully prosecuted grant fraud cases. This has been used by civil and criminal Assistant United States Attorneys across the country to facilitate prosecutions of individuals who have defrauded grant-funding agencies and/or the SBIR/STTR set aside programs.

In FY 2017, OI hosted its fifth Suspension and Debarment Workshop. These free events (which are now co-sponsored by the Interagency Suspension and Debarment Council) have trained hundreds of individuals from OIGs, Suspension and Debarment Offices, Offices of General Counsel and United States Attorney's Offices. As a result of these workshops, several agencies that were not previously using suspensions or debarments to protect federal funds have begun to do so, and agencies that were using these critical tools have strengthened their practices and identified more robust ways to protect federal funds.

OIG Support Functions. Most office-wide support functions fall under the executive leadership of an Assistant Inspector General (who also serves as OIG's Legal Counsel) and are functionally encompassed within two operating units—an immediate office and a management division.

Immediate office functions comprise those that have historically worked together, but which were formerly

aligned under the direct supervision of the Inspector General—legal, legislative/congressional, and external affairs (including public/media contacts). The staff also actively supports government-wide projects in which NSF OIG has taken a leadership role, such as increasing the use and effectiveness of suspension and debarment remedies to protect taxpayer funds.

Besides providing comprehensive legal advice, counsel, and critical analysis (including review of all audit and inspection reports) to the IG and all OIG divisions, the legal activity also administers financial disclosure requirements for OIG staff; performs certain functions related to the Freedom of Information and Privacy Acts; represents the office in external forums; and also enables the office to engage in proactive efforts (such as training and routine reviews) to help OIG staff recognize and deal with legal concerns as early as possible.

OIG's management/administrative arm is responsible for performing strategic planning/budgeting, procurement, human resources, and administrative support and is currently comprised of just three staff. Functional alignment of the two areas under a single executive subordinate to the IG has saved money and afforded some synergistic benefits to the organization. No additions to staff in FY 2019 are contemplated. To assure that there are adequate resources available for our core mission of audits and investigations, support functions across the OIG have been streamlined to the maximum extent practical.

Information Technology. Spending on hardware, software, and IT services is expected to remain at a reduced level through FY 2019. OIG plans to reduce its costs for computers and printers by lengthening their replacement cycle and phasing out the use of desktop printers.

MAJOR MULTI-USER RESEARCH FACILITIES

Major Multi-User Research Facilities Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Total Research and Related Activities	**$995.01**	**-**	**$1,105.09**	**$110.08**	**11.1%**
Operations and Maintenance of Existing Facilities	703.66	-	700.91	-2.75	-0.4%
Federally Funded Research and Development Centers	216.80	-	209.81	-6.99	-3.2%
Operations and Maintenance of Facilities under Construction	63.76	-	84.00	20.24	31.7%
R&RA Planning and Concept Development	10.79	-	6.67	-4.12	-38.2%
R&RA Facilities Construction	-	-	103.70	103.70	N/A
Major Research Equipment and Facilities Construction	**$222.45**	**-**	**$93.65**	**-$128.80**	**-57.9%**
Total, Major Multi-User Research Facilities	**$1,217.47**	**-**	**$1,198.74**	**-$18.73**	**-1.5%**

NSF investments provide state-of-the-art tools for research and education. These include major multi-user research facilities such as instrumentation networks, observatories, accelerators, detectors, telescopes, research vessels, aircraft, and simulators. In addition, investments in cyber-enabled and geographically 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, federal agencies, and international partners to ensure they are complementary and well integrated. Planning, operations, and maintenance of major multi-user facilities are funded through the R&RA account. Most construction is funded through the MREFC account. An exception to this is the Antarctic Infrastructure Modernization for Science (AIMS) construction project, funded through R&RA.

In FY 2018, NSF created the new position of Chief Officer for Research Facilities in the Office of the Director, to enhance oversight of major multi-user research facilities throughout their complete lifecycle. The individual in that position serves as the senior agency official whose responsibility is oversight of the development, construction, and operations of major multi-user research facilities across the Foundation, as required by Section 110 of the American Innovation and Competitiveness Act (P.L. 114-329).

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 major facility projects. Information on projects under construction funded through NSF's MREFC account is provided in the MREFC chapter. Information on the AIMS construction project can be found in the Office of Polar Programs chapter in the R&RA section.

Major Multi-User Research Facilities Funding, by Project

(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
Operations and Maintenance of Existing Facilities	**$703.66**	**-**	**$700.91**	**-$2.75**	**-0.4%**
Engineering					
National Nanotechnology Coordinated Infrastructure (NNCI)	15.55	-	14.78	-0.77	-5.0%
Natural Hazards Engineering Research Infrastructure (NHERI)	14.99	-	11.75	-3.24	-21.6%
Geosciences					
Academic Research Fleet[1]	82.03	-	77.80	-4.23	-5.2%
Geodesy Advancing Geosciences and EarthScope (GAGE)	13.10	-	12.19	-0.91	-6.9%
International Ocean Discovery Program (IODP)	48.00	-	48.00	-	0.0%
Ocean Observatories Initiative (OOI)[2]	0.34	-	40.00	39.66	11638.8%
Polar Facilities and Logistics	330.30	-	303.94	-26.36	-8.0%
Seismological Facilities for the Advancement of Geoscience & EarthScope (SAGE)	26.05	-	24.16	-1.89	-7.3%
Mathematical and Physical Sciences					
Arecibo Observatory	8.00	-	6.08	-1.92	-24.0%
Cornell High Energy Synchrotron Source (CHESS)	26.20	-	10.00	-16.20	-61.8%
Gemini Observatory	24.24	-	21.66	-2.58	-10.6%
IceCube Neutrino Observatory	7.00	-	7.00	-0.00	0.0%
Large Hadron Collider (LHC)[3]	16.00	-	16.00	0.00	0.0%
Laser Interferometer Gravitational Wave Observatory (LIGO)	41.93	-	45.00	3.07	7.3%
National High Magnetic Field Laboratory (NHMFL)	23.15	-	35.76	12.61	54.5%
National Superconducting Cyclotron Laboratory (NSCL)	24.00	-	24.00	-	0.0%
Other Facilities[4]	2.79	-	2.79	0.00	0.1%
Federally Funded Research and Development Centers[5]	**$216.80**	**-**	**$209.81**	**-$6.99**	**-3.2%**
National Center for Atmospheric Research (NCAR)	99.70	-	94.70	-5.00	-5.0%
National Optical Astronomy Observatory (NOAO)	22.99	-	20.13	-2.86	-12.4%
National Radio Astronomy Observatory (NRAO)[6]	76.66	-	79.13	2.47	3.2%
Other Astronomical Facilities[7]	11.45	-	11.85	0.40	3.5%
National Solar Observatory (NSO)[8]	6.00	-	4.00	-2.00	-33.3%
Operations and Maintenance of Facilities under Construction	**$63.76**	**-**	**$84.00**	**$20.24**	**31.7%**
Daniel K. Inouye Solar Telescope (DKIST)[9]	13.50	-	18.50	5.00	37.0%
Large Synoptic Survey Telescope (LSST)	-	-	0.50	0.50	N/A
National Ecological Observatory Network (NEON)	50.26	-	65.00	14.74	29.3%
R&RA Planning and Concept Development	**$10.79**	**-**	**$6.67**	**-$4.12**	**-38.2%**
Pre-construction Planning[10]	10.79	-	6.67	-4.12	-38.2%
R&RA Facilities Construction[11]	**-**	**-**	**103.70**	**103.70**	**N/A**
Major Research Equipment and Facilities Construction	**$222.45**	**-**	**$93.65**	**-$128.80**	**-57.9%**
Total, Major Multi-User Research Facilities	**$1,217.47**	**-**	**$1,198.74**	**-$18.73**	**-1.5%**

[1] Includes ship operations and upgrade support. Regional Class Research Vessels (RCRV) funding is no longer included on this line as it began MREFC construction in FY 2017.

[2] The FY 2017 budget of $340,000 reflects only the incremental support necessary to enable the potential transition of managing institutions associated with the competition for a new operation and management award of the OOI. FY 2017 operations and maintenance were funded in a prior year.

[3] Excludes $5.71 million in FY 2017 and $6.30 million in FY 2019 for planning for a potential High-Lumosity LHC upgrade. That funding is captured on the R&RA Planning and Concept Development line.

[4] Includes support for the Center for High Resolution Neutron Scattering (CHRNS).

[5] Excludes support for the Office of Science and Technology Policy Institute, which is a Federally Funded Research and Development Center but not a multi-user research facility.

[6] Includes operations and maintenance support for the Atacama Large Millimeter/submillimter Array (ALMA).

[7] Includes support for the Green Bank Observatory and the Long Baseline Observatory.

[8] Excludes $11.50 million in FY 2017 and $16.50 million in FY 2019 for operations and maintenance support for the DKIST facility construction project. That funding is captured within the totals presented on the DKIST line.

[9] Of total DKIST funding presented, $11.50 million in FY 2017 and $16.50 million in FY 2019 are for operations and maintenance support provided through NSO and $2.0 million is for cultural mitigation activities as agreed to during the environmental compliance process.

[10] Pre-construction planning includes funding for potential next generation multi-user facilities. This line reflects funding for Antarctic Infrastructure Modernization for Science (AIMS) and a potential High-Lumosity LHC upgrade in FY 2017 and FY 2019. AIMS begins construction in FY 2019.

[11] Funding for R&RA Projects under construction in this table reflects support for the AIMS project.

NSF Facilities Investments in FY 2019

The following pages contain information on NSF's ongoing facilities in FY 2019.

ACADEMIC RESEARCH FLEET (ARF) **$77,800,000**
-$4,230,000 / - 5.2%

Academic Research Fleet Funding
(Dollars in Millions)

FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Percent
$82.03	-	$77.80	-$4.23	-5.2%

The U.S. Academic Research Fleet included 18 vessels in calendar year 2017 with the two new Office of Naval Research (ONR) vessels being fully integrated into the fleet. The vessels in ARF range in size, endurance, and capabilities, enabling NSF and other federally- and state-funded scientists to conduct ocean science and technology research with a diverse fleet capable of operating in coastal and open ocean waters. Funding for ARF includes investments in ship operations; shipboard scientific support equipment; oceanographic instrumentation and technical services; and submersible support. Funding levels reported here reflect investments by the Division of Ocean Sciences (OCE) within GEO. 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*[1] published in May 2013. Details on these construction activities are contained in the Fleet Modernization section.

Total Obligations for ARF
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	ESTIMATES FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
Operations & Maintenance	$82.03	-	$77.80	$77.80	$77.80	$77.80	$77.80	$77.80
Fleet Modernization								
Regional Class Research Vessel	2.11	-	-	-	-	-	-	-
Total	**$84.14**	**-**	**$77.80**	**$77.80**	**$77.80**	**$77.80**	**$77.80**	**$77.80**

ARF serves as the main platform for the collection of data, testing of hypotheses about the structure and dynamics of the ocean, and the development and testing of novel technological instrumentation. 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.

ARF is financially 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 over the past several years, including 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.

[1] www.nopp.org/wp-content/uploads/2010/03/federal_oceanographic_fleet_status_report.pdf

Funding for scientists using the fleet is provided by 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, Division of Atmospheric and Geospace Sciences, OPP, and 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 2019 funding level of $77.80 million will support approximately 1,675 ship operating days, and includes the entry of *R/V Neil Armstrong* and *R/V Sally Ride*, the two new vessels delivered by ONR in 2016 into the fleet.

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 day-rate negotiations for ARF, regardless of owner. In addition, NSF oversees the fleet through Business Systems Reviews, site visits, ship inspections, and participation at the UNOLS Council and various 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.
- After an in-depth review of the application of rate structures on ARF ship-related activities, NSF and ONR are in the process of transitioning the accounting of Fleet activities into a Specialized Service Facility in accordance with OMB's Uniform Guidance for Federal Awards 2 CFR 200.468.
- 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 and technological research will be needed far into the future. Documents supporting this need include the *Final Recommendations of the Interagency Ocean Policy Task Force*[2] 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*[3] published in 2009, and *Critical Infrastructure for Ocean Research and Societal Needs in 2030*[4] published in 2011. In coordination with UNOLS and the other federal agencies that invest in ocean research, the Interagency Working Group on Facilities and Infrastructure (IWG-FI) published a *Federal Oceanographic Fleet Status Report*[5] in May 2013, reviewing the status and describing plans for modernizing the Federal Oceanographic Fleet, which includes both the Academic Research Fleet and the survey ships. This report was updated in March of 2016.[6] In January 2015, the National Academy of Sciences Report *Sea Change 2015-2025 Decadal Survey of Ocean Sciences*[7] identified the U.S. Academic Research Fleet as having "the strongest match between current infrastructure and the decadal science priorities" and emphasized the overall importance of ships in all of the NAS-identified ocean science and technology priorities. 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

[2] https://obamawhitehouse.archives.gov/files/documents/OPTF_FinalRecs.pdf
[3] www.nap.edu/catalog/12775/science-at-sea-meeting-future-oceanographic-goals-with-a-robust
[4] www.nap.edu/catalog/13081/critical-infrastructure-for-ocean-research-and-societal-needs-in-2030
[5] www.nopp.org/wp-content/uploads/2010/03/federal_oceanographic_fleet_status_report.pdf
[6] www.nopp.org/wp-content/uploads/2016/06/federal_fleet_status_report_final_03.2016.pdf
[7] www.nap.edu/catalog/21655/sea-change-2015-2025-decadal-survey-of-ocean-sciences

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 and Submersible Support, 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. Initial funds to initiate construction were requested in FY 2017. The RCRV will address requirements across government agencies for research vessels in support of ocean science research as discussed in the Fleet Status Report Update of 2016. For additional information on RCRV please refer to the MREFC chapter.
- *R/V Sikuliaq*, formerly the Alaska Region Research Vessel (ARRV): The *R/V Sikuliaq* represents NSF's first major contribution to fleet renewal in over twenty years. Delivery of *R/V Sikuliaq* 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. *R/V Sikuliaq* successfully completed ice trials in the Bering Sea and three science cruises in the Arctic Ocean. All final MREFC project activities were closed out under budget by March 31, 2016. *R/V Sikuliaq* provides a sophisticated and significantly larger platform for scientists, as well as graduate and undergraduate students, to participate in complex multidisciplinary research activities and enables the training of the next generation of scientists with the latest equipment and technology. *R/V Sikuliaq* greatly expands research and technology capabilities in the Arctic, providing up to 270-300 science days at sea annually.

Renewal/Recompetition/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, with upcoming renewals underway in FY 2018. Awardees are subject to additional oversight measures, including quarterly safety and financial reporting, the use of NSF Business System Reviews, 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 State University. For *R/V Sikuliaq*, a re-compete clause in ten years (2024) was included in the initial cooperative agreement for operations. This clause will be added to all renewals of NSF owned vessels.

ARECIBO OBSERVATORY (ARECIBO) **$6,080,000**
-$1,920,000 / -24.0%

Arecibo Observatory Funding
(Dollars in Millions)

FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Percent
$8.00	-	$6.08	-$1.92	-24.0%

Arecibo is a center for multidisciplinary research and education with advanced observational facilities. The observatory's principal facility is one of the world's largest single-dish radio/radar telescopes, 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 (SRI) and subrecipients, Universities Space Research Association (USRA) and Universidad Metropolitana (UMET), under a cooperative agreement with NSF that initially ran from October 1, 2011 to September 30, 2016, and was extended by 18 months to March 31, 2018. 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 subject matter experts from outside the observatory are consulted for reviews. NSF does not provide awards targeted specifically for use of Arecibo, although some Arecibo users are supported through NSF or NASA grants to pursue scientific programs that require use of the facility.

Currently, Arecibo is staffed at about 120 full-time equivalent (FTE) employees, of which about 100 are funded by NSF. The remaining FTEs are supported by a grant from NASA, by the Angel Ramos Foundation Visitor Center, and by other funding sources. Staff include approximately 20 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.

Along with the entire island of Puerto Rico, Arecibo Observatory was severely impacted by Hurricane Maria, which struck on September 20, 2017. The observatory ceased regular operations shortly before Maria's Puerto Rico landfall. Commercial power was restored on December 9, 2017, and most normal observatory operations resumed by the end of December. Funding for observatory repairs are provided in the Bipartisan Budget Act of 2018.

Total Obligations for Arecibo
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	**ESTIMATES**[1] FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
Operations & Maintenance (MPS)	$3.90	-	$3.05	$2.13	$1.50	$1.13	$1.00	$1.00
Operations & Maintenance (GEO)	4.10	-	$3.03	$2.13	$1.50	$1.13	$1.00	$1.00
Total	**$8.00**	**-**	**$6.08**	**$4.25**	**$3.00**	**$2.25**	**$2.00**	**$2.00**

[1] The current cooperative agreement, initially scheduled to end in FY 2016, has been extended through 31 March 2018.

Arecibo is jointly supported by the MPS Division of Astronomical Sciences (AST) and the GEO Division of Atmospheric and Geospace Sciences (AGS). Based on the 2006 AST Senior Review recommendations, AST and AGS reduced support for the Arecibo Observatory. An external review of the AST portfolio was completed in 2012, and an external review of the AGS portfolio was completed in 2016.

In 2012, the AST Portfolio Review Committee recommended "continued AST involvement in Arecibo be re-evaluated later in the decade in light of the science opportunities and budget forecasts at that time."[8] The New Worlds, New Horizons: Midterm Assessment (August 2016) reinforced this, with Recommendation 3.1 noting: "The NSF should proceed with divestment from ground-based facilities that have a lower scientific impact."[9]

The Geospace Section (GS) Portfolio Review Committee was charged by the NSF Advisory Committee for Geosciences to review the most promising Geospace science strategies and critical capabilities and to reconcile these with the science goals described by the 2013 Decadal Survey for Solar and Space Physics.[10] The GS is associated with AGS and its portfolio includes grant programs in upper-atmospheric sciences, space science, and space weather. This GS portfolio review was carried out using the assumption of an inflation-adjusted, flat budget for GS over the next decade to FY 2026. The GS Portfolio Review Committee recommendations include the reduction of annual AGS Arecibo Observatory funding from $4.10 million to $1.10 million by 2020.

GEO commissioned a review from a second panel assembled by the National Academies that assessed the process by which the GS Portfolio Review Committee reached their findings and recommendations. The panel published[11] the results of this review in early 2017 and, for Arecibo, reiterated the recommendations of the GS Portfolio Review Committee.

Because of these potential changes, NSF prepared an Environmental Impact Statement (EIS) to evaluate proposed operational changes at Arecibo due to funding constraints, pursuant to the National Environmental Policy Act. NSF also completed its compliance obligations with the National Historic Preservation Act, and the Endangered Species Act. NSF prepared a Final EIS, which was published in August 2017.[12] Following publication of the EIS, NSF published a Record of Decision[13] in November 2017, which formalizes the selection of NSF's preferred alternative: to collaborate with interested parties to maintain science-focused operations at the Observatory with reduced agency funding.

NSF issued a solicitation in January 2017 requesting proposals to provide continued operations and management of Arecibo for five years, but at reduced funding. The planned NSF funding profile presented in the solicitation gradually tapered NSF support to $2.0 million by the 5th year of the award. In February 2018, NSF announced an award to University of Central Florida (UCF) to undertake formal transition activities expected to lead to UCF assumption of full operations and management responsibilities for Arecibo Observatory. The award ensures continued science-focused operations that will maintain the Observatory's existing research lines of atmospheric, planetary and astronomical research.

Partnerships and Other Funding Sources: Arecibo supplements NSF support with funding provided by other federal and non-federal sources. Since FY 2010, the NASA Near Earth Object Observation Program has committed $2.0 million annually to Arecibo for the planetary radar program; this increased to $3.60 million for FY 2013, with more observing time allocated to the NASA program. In FY 2019, NASA support is expected to continue at approximately $3.60 million.

[8] www.nsf.gov/mps/ast/ast_portfolio_review.jsp
[9] www.nap.edu/read/23560/chapter/1
[10] www.nap.edu/read/13060/chapter/1
[11] www.nsf.gov/geo/adgeo/geospace-review/geospace-portfolio-review-final-rpt-2016.pdf
[12] www.nsf.gov/mps/ast/env_impact_reviews/arecibo/arecibo_feis.jsp
[13] www.nsf.gov/mps/ast/env_impact_reviews/arecibo/arecibo_rod.jsp

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. Over 350 students have participated participated in REU programs at Arecibo. In collaboration with the National Radio Astronomy Observatory, 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. Exhibits at the visitor center were updated, and physical renovations to the visitor center building were completed in FY 2016. These improvements were funded by the Angel Ramos Foundation and the Ana G. Méndez University System and were formally approved by NSF. With funds received from the Puerto Rico Department of Education, Arecibo has hosted numerous teacher workshops and has trained approximately 500 teachers. This program integrates formal activities at the Angel Ramos Foundation Visitor Center into the STEM curriculum in Puerto Rico. Arecibo also hosts several meetings each year within a wide variety of scientific disciplines.

An 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.*

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 proposals. The telescope is currently oversubscribed, counting ongoing astronomy surveys, new astronomy projects, solar system observations, and atmospheric sciences programs. About 75 percent of astronomy users conduct their observing remotely via networked control software, while radar observations typically employ on-site users.

Management and Oversight

- AST, $3.05 million: AST funding will maintain basic operations costs and science programs in passive radio astronomy. As recommended by the 2006 AST Senior Review, AST funding for Arecibo has been gradually reduced.
- AGS, $3.03 million: AGS funding will support basic operations costs and science programs in aeronomy and space physics, including space weather.
- NSF Structure: The lead NSF program officer in AST, in close cooperation with a program officer in AGS and in consultation with community representatives, provides ongoing oversight. The program officers make use of detailed annual program plans, long-range plans, quarterly technical and financial reports, and annual reports submitted by the management and operations awardee. They also attend awardee governance committee meetings, as appropriate. To address issues as they arise, program officers work closely with other NSF offices such as the Office of the General Counsel, the Division of Acquisition and Cooperative Support and the Large Facilities Office in the Office of Budget, Finance, and Award Management. AST and AGS program officers conduct periodic site visits and frequent, regular, teleconferences.
- External Structure: Management is via a cooperative agreement. In February 2018 NSF announced an

award to UCF to undertake formal transition activities leading to UCF assumption of full operations and management responsibilities for Arecibo Observatory. NSF is currently negotiating the operations and management award with UCF, including details of the external management and oversight structure.

- Reviews:
  - In January 2017 NSF issued a solicitation requesting proposals to provide continued operations and management of Arecibo for five years, but at reduced funding. Proposals received in response to this solicitation were afforded extensive NSF internal review together with formal review by a panel of external experts in observatory management and operations.
  - AST and AGS jointly conduct annual external reviews of Arecibo program plans; the most recent such review was held in January 2017.

Renewal/Recompetition/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. This followed a competitive process for a new five-year cooperative agreement, consistent with National Science Board policy. This agreement was in effect through September 30, 2016, and was extended through March 31, 2018. In January 2017 NSF issued a solicitation for continued operations and management of Arecibo Observatory. Following a thorough review process, in February 2018, NSF announced an award to UCF to undertake formal transition activities expected to lead to UCF assumption of full operations and management responsibilities. NSF is currently negotiating the full operations and management award with UCF. The duration of this award is expected to be five years.

CORNELL HIGH ENERGY SYNCHROTRON SOURCE (CHESS) **$10,000,000**
-$16,200,000 / -61.8%

Cornell High Energy Synchrotron Source Funding

(Dollars in Millions)

FY 2017 Actual[1]	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
$26.20	-	$10.00	-$16.20	-61.8%

[1] Includes $8.20 million in forward funding for the FY 2018 award increment. Without this action, the change over FY 2017 Actual would be -$8.0 million, or -44.4%.

CHESS is a high-intensity, high-energy X-ray user facility located on the campus of Cornell University in Ithaca, NY. 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, engineering, and environmental sciences. Emphasis areas 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 MPS Division of Materials Research (DMR).

CHESS is a national user facility accessed through a competitive proposal review process. The primary function of CHESS staff is to maintain and operate the facility and to assist users. Approximately 850 users annually 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 topic is done in collaboration with NIH. An annual meeting of users and several workshops help disseminate results from the facility.

CHESS supports users from academia, industry, and national laboratories. CHESS has developed 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 Department of Energy (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, DOE's 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 CHESS-developed undulators, and other innovations such as high flux X-ray optics, are impacting synchrotron science worldwide.

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. The CHESS education and

outreach program annually impacts over 6,000 people of all ages, including over 1,300 visitors touring the Cornell facilities. Each year, about 60 Ph.D. degrees are 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.

With support from the State of New York, CHESS is currently upgrading the source ring to a high energy hard X-ray synchrotron source. In FY 2017, NSF conducted a review of the science case for this new X-ray source, named CHESS-U, and determined that this upgrade would not provide a sufficiently unique facility to justify continued stewardship of the source by NSF. This led to the decision to continue funding CHESS operations until March 31, 2019 and to accept a transition proposal in FY 2018. This proposal would establish a partnership model, whereby NSF would consider investing in the most unique experimental components but no longer support full operation of the source. In the FY 2019 Budget Request, NSF proposes to support CHESS in its transition plan at the level of $10.0 million.

Total Obligations for CHESS

(Dollars in Millions)

	FY 2017	FY 2018	FY 2019	**ESTIMATES**[1]				
	Actual	(TBD)	Request	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
Operations & Maintenance (MPS)[2]	$16.20	-	$10.00	$5.00	$5.00	$5.00	$5.00	$5.00
Operations & Maintenance (BIO)	5.00	-	-	-	-	-	-	-
Operations & Maintenance (ENG)	5.00	-	-	-	-	-	-	-
Total	**$26.20**	-	**$10.00**	**$5.00**	**$5.00**	**$5.00**	**$5.00**	**$5.00**

[1] Outyear funding estimates are for planning purposes only. The current cooperative agreement ends in March 2019. Transition of CHESS from an NSF stewardship to a partnership model began in FY 2018; future funding is dependent on proposal review.

[2] The FY 2017 Actual for MPS/DMR includes $8.20 million in forward funding for the FY 2018 award increment.

Management and Oversight

- NSF Structure: CHESS is supported by MPS through a cooperative agreement with Cornell University. A MPS/DMR program director is the primary contact with the facility. NIH provides additional support for CHESS operations through the Macromolecular Diffraction at the Cornell High Energy Synchrotron Source (MacCHESS) award. A Joint Oversight Group (JOG) was established to better coordinate the CHESS and MacCHESS awards. The JOG serves as a vehicle to keep interested parties informed and includes MPS, ENG, BIO, and NIH program directors.
- External structure: The Cornell Laboratory of Accelerator-baSed Sciences and Education (CLASSE), which falls under Cornell's Vice Provost for Research, administers CHESS. 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. 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, as well as the 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 composed of members from the research community, representatives from NIH attend these site visits. In addition to these yearly scientific reviews, CHESS undergoes periodic business systems review by the NSF Large Facilities Office and Division of Acquisition and Cooperative Support. Recent and upcoming reviews include:
  - Review of science case for state funded upgrade of CHESS (CHESS-U), October 26-28, 2016.
  - Review of the CHESS Business Plan for transition, November 2017.

- NSF received a Transition Proposal for peer review on January 31, 2018.
- Review of Transition Proposal, 2018–2019, subject to the availability of funds.

Renewal/Recompetition/Termination
The end date of the current CHESS award is March 2019.

GEMINI OBSERVATORY (GEMINI) **$21,660,000**
-$2,580,000 / -10.6%

Gemini Observatory Funding
(Dollars in Millions)

FY 2017 Actual[1]	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
$24.24	-	$21.66	-$2.58	-10.6%

[1] Includes a one-time technical reobligation of $3.74 million at the end of an expiring cooperative support agreement. Without this action, the change from FY 2017 to FY 2019 would be $1.16 million or 5.7 percent.

The Gemini Observatory consists of twin optical/infrared 8-meter telescopes, one each in the northern and southern hemispheres, thereby providing complete coverage of the sky. Gemini North sits atop Mauna Kea, Hawai'i at an elevation of 4,200 meters, while Gemini South is located on the 2,700-meter summit of Cerro Pachón, Chile. 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 at Gemini are the age and rate of expansion of the universe, the origin of the "dark energy" that drives cosmic acceleration, the nature of non-luminous matter, the processes that give rise to the formation and evolving structures of galaxies, and the birth of stars and their planetary systems. Technological advances incorporated into the design of the two telescopes optimize their imaging capabilities and infrared performance as well as their ability to quickly swap instruments in response to changing atmospheric conditions. Gemini's flexible observing modes make it ideal for reacting rapidly to opportunities that arise in the new era of multi-messenger astronomy. Gemini was one of the first observatories used to characterize the recent neutron star merger/gravitational wave event GW170817, and also responded rapidly to the recently discovered interstellar asteroid A/2017 U1 whose orbit crossed the solar system in October 2017.

The research agencies that currently form the Gemini international partnership include: NSF; the National Research Council of Canada; the Ministério da Ciência, Tecnologia e Inovação of Brazil; the Ministerio de Ciencia, Tecnología e Innovación Productiva of Argentina; and the Comisión Nacional de Investigación Científica y Tecnológica of Chile. These five agencies are signatories to the Gemini International Agreement, which currently covers January 1, 2016 through December 31, 2021.

Gemini helps educate astronomy and engineering students through undergraduate internship programs in both Hawai'i and Chile. Gemini also provides an engaging focal point for public outreach and student training in all of the partner countries. Gemini-sponsored activities attract students and teachers at all levels of elementary through high school education. The unique Gemini-led *Journey Through the Universe* program in Hilo, Hawai'i (now in its 14th year) and its sister activity, *Viaje al Universo* in La Serena, Chile, bring astronomy into the classroom through week-long annual events that involve dozens of astronomers from Gemini as well as from many of the other astronomical facilities at each location. Gemini staff also provides guidance and support to the 'Imiloa Astronomy Center, a public facility in Hilo that seeks to advance the integration of science and indigenous culture through education.

The observatory supports four facility-class instruments at each telescope as well as a vigorous visiting instrument program. Each telescope is equipped with state-of-the-art adaptive optics and laser guide star systems which greatly improve the ability to correct for atmospheric blurring. The advanced multi-conjugate adaptive optics system on Gemini South continues to lead the world, providing near-infrared

images that are often sharper than those observed from space with smaller telescopes, and which cover a field-of-view on the sky that is wider than any competing system on the ground.

The observatory is actively developing new imagers and spectrometers. By agreement, the observatory partners contribute an additional amount (10 percent of their annual operations contribution) to the new instrument fund. The Gemini High-resolution Optical SpecTrograph (GHOST), a workhorse instrument for studying a vast array of astronomical objects, is nearing completion. A contract was signed in early 2017 for a new 8-beam optical/infrared spectrograph, OCTOCAM, that will be used to characterize exotic transient phenomena discovered with the Large Synoptic Survey Telescope (LSST) in the 2020s. This latest instrument selection directly responds to the need for an LSST follow-up instrument, as recommended in the 2012 NSF Division of Astronomical Sciences (AST) Portfolio Review report *Advancing Astronomy in the Coming Decade: Opportunities and Challenges,*[14] in the 2015 National Academies report *Optimizing the U.S. Ground-Based Optical and Infrared System*,[15] and in the 2016 KAVLI Futures Symposium report *Maximizing Science in the Era of LSST: A Community Based Study of Needed US OIR Capabilities*.[16]

Construction of the telescopes and their instrumentation involved a large number of industrial entities in several countries, with areas of specialization that included large and complex optical systems, engineering, electronics, electro-mechanical systems, and computing. Continued development in these areas is reflected in the instrumentation and facilities renewal activities that are incorporated into the overall budget.

The U.S. share of Gemini Observatory observing time is open to proposals from any researcher in the U.S. astronomical community, with peer-review committees providing merit-based telescope time. NSF does not provide awards targeted specifically for the 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.

Total Obligations for Gemini

(Dollars in Millions)

	FY 2017	FY 2018	FY 2019	ESTIMATES[1]				
	Actual	(TBD)	Request	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
Operations & Maintenance[2]	$24.24	-	$21.66	$22.31	$22.98	$23.67	$23.67	$23.67

[1] Outyear funding estimates are for planning purposes only. The current cooperative agreement ends December 2022.

[2] FY 2017 includes a one-time technical reobligation of $3.74 million at the end of an expiring cooperative support agreement.

In the FY 2019 Budget Request, NSF plans to maintain full operations of Gemini Observatory through the entire fiscal year. The Budget Request of $19.69 million includes the full contribution of the NSF (U.S.) share of facility operations costs. However, it does not include the $1.97 million NSF (U.S.) contribution to the Gemini Instrument Development Fund, which is obtained through additional partner contributions of 10 percent of annual operations contributions, and is intended to support future instrument development, as agreed to in the Gemini partnership agreement.

Management and Oversight

- Governance Structure: The observatory is governed by the Gemini Board, which was established by the Gemini International Agreement signed by the participating agencies. This board meets at least twice a year and acts as the primary forum for interactions and decisions among the Participants in the Gemini Agreement; the Gemini Board ensures that Gemini is managed and operated in accordance with the Agreement, and is the body with overall budgetary and policy control over the observatory. NSF

[14] www.aura-astronomy.org/news/2012/ast_portfolio_review_report.pdf
[15] www.nap.edu/catalog/21722/optimizing-the-us-ground-based-optical-and-infrared-astronomy-system
[16] www.noao.edu/meetings/lsst-oir-study/

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; NSF appoints the five non-NSF U.S. members.

- Managing Organization: The Gemini Observatory is currently managed by the Association of Universities for Research in Astronomy, Inc. (AURA) on behalf of the partnership through a cooperative agreement with NSF. The current cooperative agreement covers January 1, 2017 to December 31, 2022. AURA conducts its own management reviews through oversight committees.
- NSF Structure: NSF has one seat on the Gemini Board, currently occupied by the AST program officer responsible for Gemini programmatic oversight. Another NSF staff member serves as Board executive secretary. 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, participates in various Board sponsored sub-committees, and approves funding actions, reports, and contracts.
- Reviews: NSF conducts periodic reviews of the management and operation of the observatory, and of AURA's financial systems. NSF most recently conducted a Business System Review (BSR) of the observatory and AURA's centralized administrative services in 2013. In April 2017, NSF conducted a Gemini Accounting System Audit, and plans to conduct a new BSR in 2018 or 2019.

Renewal/Recompetition/Termination

The United Kingdom withdrew from the Gemini partnership at the end of 2012, requiring about a 24 percent budget reduction for overall facility management and operations. More recently, Australia, a 6.3 percent partner in 2015, first moved to a limited-term participation and then ceased participation entirely in late 2017. South Korea has a similar limited-term, year-to-year arrangement through the end of 2018, though discussions are underway regarding full partnership from 2019 onwards at a roughly 5 percent level. The next participant assessment point is scheduled for 2018, at which time existing partners will establish participation levels in the Gemini Observatory beyond December 2021.

The Gemini telescopes atop Maunakea in Hawai'i (left) and Cerro Pachón in Chile (right). *Credit: Gemini Observatory*

The cooperative agreement for managing Gemini that expired at the end of 2016 included a plan to support the transition to the new operations model under the reduced budget due to changes in international partner participation. Reductions in project scope included a decreased facility-class instrument complement on each telescope, cost savings from a shift to remote telescope operations from the sea level base facilities in Hawai'i and Chile, a redesign of the data archive, and prioritization of serving the partner user communities over internal scientific research activities. These and other transition projects have now been successfully completed.

Prior to the completion of the aforementioned transition program, re-competition of the management and operation of Gemini was conducted in 2014-2015. The National Science Board authorized a new cooperative agreement with AURA in February 2016 that covers January 2017 through December 2022.

GEODESY ADVANCING GEOSCIENCES AND EARTHSCOPE (GAGE) **$12,190,000**
-$91,000 / -6.9%

Geodesy Advancing Geosciences and Earthscope Funding
(Dollars in Millions)

FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Percent
$13.10	-	$12.19	-$0.91	-6.9%

Geodesy Advancing Geosciences and EarthScope comprises 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, a consortium of 115 U.S. universities and non-profit institutions with research and teaching programs in geophysics and geodesy and 108 associate members from foreign institutions. GAGE was formed in late FY 2013 from the geodetic component of the EarthScope facility and related geodetic facilities previous managed by UNAVCO. The FY 2019 Budget Request will enable GAGE to provide key services for the geoscience research community, including global and regional observing networks, field and technical support for experiments worldwide, data management and distribution systems, and other related activities.

Over the last three decades, the Earth science research community has greatly refined our ability to determine the position and motion of points on Earth’s surface using space geodetic techniques, enabling high-resolution studies of Earth processes in a wide range of fields. 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.

Total Obligations for GAGE
(Dollars in Millions)

	FY 2017	FY 2018	FY 2019	ESTIMATES				
	Actual	(TBD)	Request	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
Operations & Maintenance	$13.10	-	$12.19	$12.19	$12.19	$12.19	$12.19	$12.19

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 (more than 720 of which transmit data in real-time with sub-second latency) distributed across the U.S., with focus on the active plate boundaries in the western contiguous U.S. and southern Alaska. Data recovery for the PBO GPS network typically exceeds 90 percent. PBO also includes 76 borehole strainmeters and 79 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. Together, data collected by these

instruments enable scientists to study the full range of deformation in the solid Earth, from the rapid shaking associated with earthquakes, through more gradual motions related to slow slip events on faults and to Earth's evolving water cycles, up to long-term plate tectonics.

- Global geodetic arrays outside of the PBO footprint are supported by GAGE in partnership with investigators. Nearly 900 continuous GPS stations from around the world are now maintained, monitored, and data compiled into the GAGE data system. GAGE supports 58 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); the ITRF is the foundation for high-precision global Earth science and other applications of geodesy such as land surveying. GAGE is also supporting the development of data distribution systems for a Caribbean region GPS and meteorological sensor network (COCONet) of more than 100 stations that support tectonic, volcano, tropical storm, and sea level change investigations.
- Community GPS receiver and geodetic technology pool includes a pool of over 680 GPS and Global Navigational Satellite System (GNSS) receivers, ancillary equipment, and six terrestrial laser scanners, which can be used by investigators for short- and long-term deployments on research projects supported via multiple Earth science programs funded by NSF.
- 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.
- 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 282 terabytes of data from GPS, laser scanning, Synthetic Aperture Radar (SAR), and borehole geophysical instruments from all GAGE components including EarthScope PBO, global continuous geodetic 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 100 km to 1,000 km is complementary to discrete GPS measurement of displacement. UNAVCO, as the manager of GAGE, brokers for cost-effective community access to the SAR imagery acquired by foreign SAR satellite systems. These data enable the wide range of Earth science studies described above.

Education and Community Engagement

The GAGE Education and Community Engagement (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 geodetic 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.

Beside its role in providing 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). GCN 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 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) in the Directorate for Geosciences, 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 EAR Division Director and Integrated Activities Section Head provide other internal oversight.
- External Structure: GAGE is managed and operated by UNAVCO, which is incorporated as a non-profit consortium representing 115 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 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 GAGE cooperative agreement began October 1, 2013, and will expire September 30, 2018. In FY 2016, in keeping with the phased integration and recompetition plan presented to the National Science Board in December 2009, NSF solicited proposals to manage and operate one or more components of a new facility to support the Earth sciences research and education community. These components are currently supported by GAGE and the related Seismological Facilities for the Advancement of Geoscience and EarthScope (SAGE). The new distributed, multi-user, national facility would support the development, deployment, management, and operational support of modern geodetic, seismic, and related geophysical instrumentation and provide services to serve national goals in basic research and education in the Earth sciences. NSF is currently reviewing proposals received in response to this facility solicitation. As part of a robust re-competition and cost review process, various NSF oversight activities have been completed and others are underway, such as an independent cost assessments to inform NSF’s cost analysis for a potential award.

ICECUBE NEUTRINO OBSERVATORY (ICECUBE) **$7,000,000**
$0 / 0%

IceCube Neutrino Observatory Funding
(Dollars in Millions)

FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Percent
$7.00	-	$7.00	-	-

IceCube is the world's first high-energy neutrino observatory and is 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. The energy and arrival direction of high-energy neutrinos ranging in energy from 100 GeV to 10 PeV (1 GeV is 10^9 electron Volts [eV]; 1TeV is 10^{12} eV; and 1 PeV is 10^{16} eV) are derived from the IceCube data stream. The IceCube collaboration has recently focused on studies of neutrino events with a deposited energy of 1 TeV and above. Astrophysical neutrinos remain the dominant component above 10 TeV. The number of these neutrinos, detected by IceCube in the range between 100 TeV and 10 PeV has already exceeded 150, and so will provide a statistically robust basis for determining the extrasolar neutrino flux.

Multi-messenger astrophysics followed the IceCube telegram on 22 September 2017, reporting a well-reconstructed track of a ~290 TeV extraterrestrial muon neutrino that pointed to the location of the bright flaring blazar (a quasi-stellar radio source associated with a supermassive black hole at the center of an active giant galaxy). Three scientific spacecraft (Fermi-LAT, AGILE, SWIFT) and one ground-based telescope (MAGIC) reported ~100 GeV-level gamma-ray observations from a direction that was consistent within 0.1° from the location of the blazar, previously located by the Fermi Large Area Telescope.

Credit: USAP Photo Library, Sven Lidstrom (sic), NSF.

Approximately one cubic kilometer of ice is instrumented with photo-multiplier (PM) tubes to detect neutrino-induced, charged reaction products that are produced when a high-energy neutrino interacts in the ice within or near the cubic kilometer fiducial volume. Since completion in 2010, the IceCube detector has been taking data in its final configuration with an uptime of well over 99 percent. To handle the high data 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.

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. The DCA closes the energy gap between the IceCube Neutrino Observatory and the Super-Kamiokande detector in

Japan, and allows effective observations of high-energy neutrinos entering from the sky of the southern hemisphere.

Total Obligations for IceCube
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	ESTIMATES FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
Operations & Maintenance (GEO)	$3.50	-	$3.50	$3.50	$3.50	$3.50	$3.50	$3.50
Operations & Maintenance (MPS)	3.50	-	3.50	3.50	3.50	3.50	3.50	3.50
Total	**$7.00**	**-**	**$7.00**	**$7.00**	**$7.00**	**$7.00**	**$7.00**	**$7.00**

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 23 U.S. institutions and 24 institutions in 11 other countries (Belgium, Germany, Sweden, Australia, Canada, Denmark, Japan, Korea, New Zealand, 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 Office of Polar Programs (OPP) and the Mathematical and Physical Sciences Directorate's (MPS) Division of Physics (PHY). Support for operations and maintenance, research and education, and outreach are shared by OPP and PHY, as well as other external 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 a two-year term, with an option to be renewed once for at most four consecutive years. 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.

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. The $ 1.0 million reduction in the U.S. operational cost contribution will likely be taken over by non-U.S. partners. This would shift the ratio of U.S.:non-U.S. PhD researchers from about 55:45 to 47:53. 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.

Approximately $4.0 million annually is provided in NSF support for U.S. institutions working on more refined and specific data analyses, data interpretation (theory support), and instrumentation upgrades is provided in response to merit-reviewed proposals, through research grants.

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 U.S. and NSF education and outreach goals. Specific outcomes include the education and training of future leaders in astrophysics, including undergraduate students, graduate students, and postdoctoral research associates; K-12 teacher scientific and 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 serving institutions; and enhanced public understanding of science through broadcast media and museum exhibits (such as the Adler Planetarium in Chicago, Illinois) 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

NSF re-competed the IceCube operations and maintenance award in FY 2016. The new award was issued on April 1, 2016 for 60 months.

INTERNATIONAL OCEAN DISCOVERY PROGRAM (IODP) **$48,000,000**
$0 / 0%

International Ocean Discovery Program Funding
(Dollars in Millions)

FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Percent
$48.00	-	$48.00	-	-

The International Ocean Discovery Program began in FY 2014 as the replacement for the Integrated Ocean Drilling Program and the prior Ocean Drilling Program. The IODP represents an international partnership of the scientists, research institutions, and funding organizations of 23 nations to explore the evolution, structure, and behavior of Earth as recorded in the ocean basins. The program management structure focuses on maximizing facility efficiency, while retaining the intellectual cooperation and exchange with NSF's international partners. 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. The 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.

Total Obligations for IODP
(Dollars in Millions)

	FY 2017	FY 2018	FY 2019	ESTIMATES				
	Actual	(TBD)	Request	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
Operations & Maintenance	$48.00	-	$48.00	$48.00	$48.00	$48.00	$48.00	$48.00

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. The FY 2019 Request of $48.0 million for operations and maintenance of the *JOIDES Resolution* will support five expeditions per year. Another commercial contractor provides down-hole-logging services. Databases and core repositories, preparing scientific publications emerging from *JOIDES Resolution* IODP expeditions, and management of international program proposal review through the IODP Science Support Office, represent additional NSF IODP science integration costs, made at minimal cost to NSF because of international contributions to the program. NSF also provides support for U.S. scientists to sail on IODP drilling platforms and to participate in IODP advisory panels through an associated program. The annual costs for the associated science integration and science support (not included in the table above) for FY 2019 are projected to be approximately $8.5 million, funded separately through the Division of Ocean Sciences (OCE).

The IODP scientific program emphasizes 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.

The umbrella IODP Forum provides a venue for all IODP entities to exchange ideas and views on the scientific progress of the program. In the current IODP, each drillship is governed by independent facility boards, each of which is unique and optimized for their respective drilling platform. In the case of the

JOIDES Resolution Facility Board (JRFB), two advisory panels review proposals and provide 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, Canada, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, 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, and through curation of *JOIDES Resolution* core samples at Japan's Kochi Core Center.

Over 3,900 scientists from 52 nations have participated on Ocean Drilling Program, Integrated Ocean Drilling Program, and International Ocean Discovery Program expeditions since 1985, including approximately 1,660 U.S. scientists from over 150 universities, government agencies, and industrial research laboratories. Samples and data have been distributed to well over 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 Science Support Office under the NSF Ocean Drilling Program (ODP). NSF's ODP is located within the Integrative Programs section, with one and a half 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 cooperative agreement for the IODP U.S. Science Support Program (USSSP).
- 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. NSF is a member of the JRFB.
- Reviews: Performance of the *JOIDES Resolution* facility is reviewed yearly by an NSF panel, in consultation with the JRFB. Substantive review of management performance regarding *JOIDES Resolution* operations occurred in the third year of the cooperative agreement (FY 2017) to guide potential 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

In FY 2013, to facilitate support for drilling proposal review, advisory panel meeting logistics, and other integrative activities for scientists participating in IODP activities (e.g., websites), the IODP Science Support Office was selected at the University of California, San Diego through a competitive process for a five-year (FY 2014 - FY 2018) cooperative agreement. In January 2018 NSF awarded a 5-year extension for this Office through FY 2023.

In FY 2014, through a competitive process, Texas A&M University was selected to be the *JOIDES Resolution* operator under a five-year (FY 2015 - FY 2019) 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. NSF is considering a possible recommendation for a Five Year Award renewal and will make a determination in FY 2018.

In FY 2015, to facilitate support for U.S. scientists participating on IODP platforms (i.e., salary and travel support) and for U.S. IODP education and outreach efforts, a new cooperative agreement was awarded, after competitive selection, to the Lamont-Doherty Earth Observatory (LDEO) of Columbia University for operation of the U.S. Science Support Program for a five-year period (FY 2015 - FY 2019).

JOIDES Resolution underway for science expedition 369, October 2017. *Credit: Gabriel Tagliard*

LARGE HADRON COLLIDER (LHC) **$22,300,000**
+$590,000 / 2.7%

Large Hadron Collider Funding
(Dollars in Millions)

FY 2017 Actual[1]	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Percent
$21.71	-	$22.30	$0.59	2.7%

[1] Includes $5.71 in FY 2016 and $6.30 million in FY 2019 for High-Lumosity LHC Upgrade planning.

LHC, an international project at the European Organization for Nuclear Research (CERN) 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, approximately 16.5 miles in circumference, providing two counter-rotating proton beams with a design energy of 7 TeV (1 TeV=1012 electron volts) per beam. It can also provide colliding beams of heavy ions, such as lead. During 2011 and 2012 ("Run 1") the LHC operated at 4 TeV per beam because of a limitation in the electrical connections between the superconducting magnets. After the connections were upgraded during a nearly two-year shutdown, Run 2 began in mid-2015 and will continue through the end of 2018 at 6.5 TeV per beam, exploring a new energy region not accessible during Run 1.

Four large particle detectors collect the data delivered by the LHC. They characterize the reaction products from high-energy proton-proton and heavy ion beam collisions. These are analyzed to investigate the fundamental properties of matter. More than 40 international funding agencies provide support for scientists to participate in experiments at the LHC. 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.

LHC data have resulted in major scientific discoveries. Foremost of these was the July 4, 2012, announcement by the CMS and ATLAS collaborations of the discovery of a particle having properties consistent with the long-sought Higgs boson, a prediction of the Standard Model of particle physics. Its existence was a prediction of the theoretical framework describing the origin of the masses of elementary particles. The experimental confirmation of this theory was recognized by the award of the 2013 Nobel Prize in Physics to François Englert and Peter Higgs. Another important discovery was announced on July 14, 2015, when the LHC-b experiment reported the discovery of a new way to aggregate quarks (the fundamental building blocks of ordinary matter) into a collection of five quarks, a combination never before observed. On June 28, 2016, the same collaboration reported the observation of another novel aggregation of quarks into novel four-quark elementary particles. The collaborations continue to search for evidence of new physical phenomena beyond the Standard Model. For example, 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. Despite no conclusive signs of new physics so far, the experimental results to date have helped tighten constraints on different models and possibilities, homing in on the most exciting areas of investigation ahead.

Total Obligations for LHC

(Dollars in Millions)

	FY 2017	FY 2018	FY 2019	ESTIMATES[1]				
	Actual	(TBD)	Request	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
Operations & Maintenance	$16.00	-	$16.00	$20.50	$20.50	$20.50	$20.50	$20.50
Upgrade Planning	5.71	-	6.30	-	-	-	-	-
Total	$21.71	-	$22.30	$20.50	$20.50	$20.50	$20.50	$20.50

[1] The current cooperative agreements end in December 2021 (CMS) and January 2022 (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.

The May 2014 report of the Particle Physics Project Prioritization Panel (P5) recommended to DOE and NSF that the highest priority strategic goal for the U.S. particle physics research program, within a global context, should be continued support for involvement in the LHC program. Within the scope of supported activities, they recommended including a further planned upgrade of the accelerator to very high luminosity (nearly ten times the luminosity of initial operation). A high luminosity upgrade will facilitate precision measurements that may reveal new physics beyond the Standard Model. This will necessitate significant enhancements to the detectors to exploit this scientific opportunity. NSF has been working with the US ATLAS and CMS detector collaborations to plan for a possible contribution to this upgrade. Supplemental funds provided through the operations award in FY 2016 and FY 2017 have enabled the collaborations to initiate a preliminary design for an NSF component.

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.

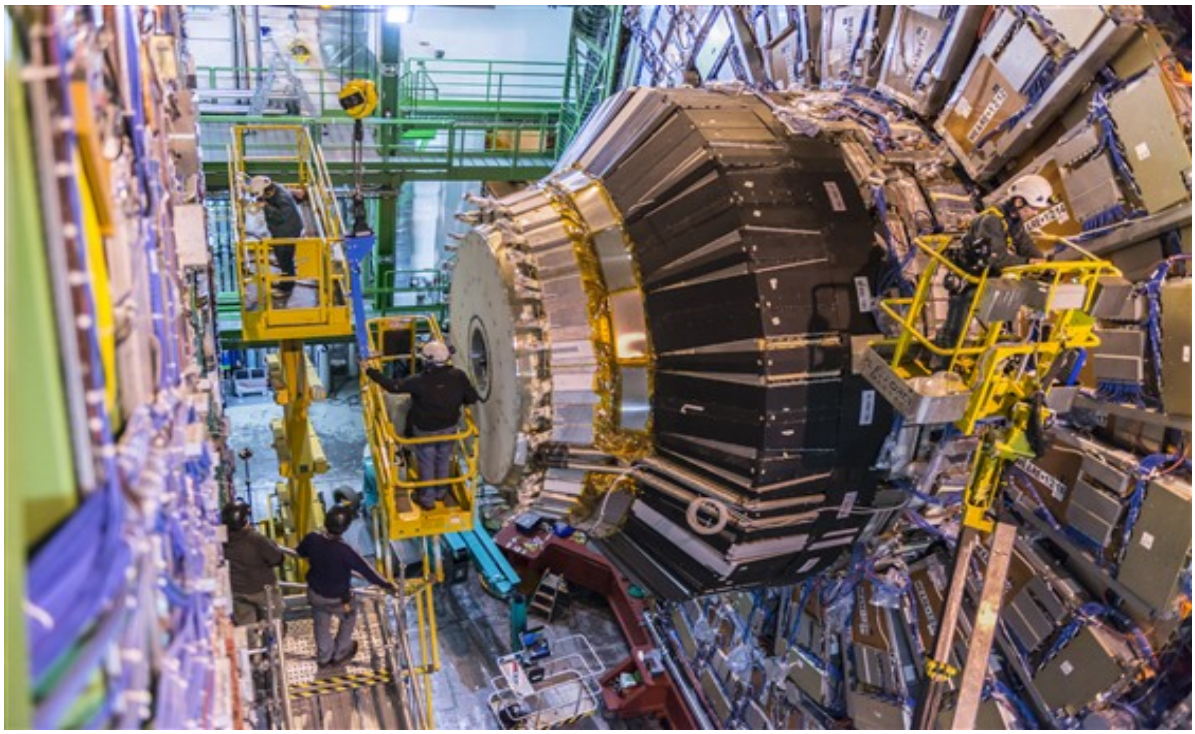
Management and Oversight

- NSF Structure: A program director in the Directorate for Mathematical and Physical Sciences, Division of Physics is responsible for day-to-day project oversight. The Division of Acquisition and Cooperative Support provides financial and administrative support. An Integrated Project Team, with representatives from the Mathematical and Physical Science Directorate, experienced program officers, the Large Facilities Office, and other areas of the Office of Budget, Finance, and Award Management, contribute to the planning activities that may lead to a major construction upgrade.
- 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 Stony Brook University for US-ATLAS.
- Reviews: There is one major management/technical review each year with a panel of external, international experts, a follow-up review six months later, as well as bi-weekly telephone reviews by NSF/DOE program directors to monitor progress. NSF and DOE conduct separate and joint external reviews of the detector upgrade activities so that each agency is fully cognizant of the activities of the other partner. The most recent major joint management/technical review was held in October 2017.

Two JOG review meetings per year monitor overall program management. The most recent JOG was held in April 2017. NSF also conducted external reviews of planning for the potential high luminosity upgrades. The most recent reviews were held in December 2017 and January 2018.

Renewal/Recompetition/Termination

Funding for operations and maintenance for LHC was renewed in FY 2017 through cooperative agreements that will expire in FY 2022.



The CMS Detector undergoing maintenance in December 2013. *Credit: CERN.*

LASER INTERFEROMETER GRAVITATIONAL-WAVE OBSERVATORY (LIGO) **$45,000,000**
+$3,070,000 / 7.3%

Laser Interferometer Gravitational-Wave Observatory Funding
(Dollars in Millions)

FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Percent
$41.93	-	$45.00	$3.07	7.3%

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 black holes, will produce gravitational radiation. On September 14, 2015, LIGO directly observed gravitational radiation from a black-hole merger, verifying this 100-year-old prediction. This is an achievement of historic importance for fundamental physics, astrophysics, and astronomy, as it opens an entirely new observational window on the universe. This achievement was announced to the world in a series of international press conferences on February 11, 2016. LIGO announced detection of a second black-hole merger on June 15, 2016. Since that time an additional three black-hole-black-hole mergers have been observed, the last, on August 14, 2017, in coincidence with the VIRGO interferometer in Italy. In October 2017, LIGO announced the first detection of a neutron star-neutron star merger on August 17, 2017. This event was also observed in the electromagnetic spectrum, from gamma rays to radio waves, by 70 telescopes around the world. These observations had the far-reaching consequence of confirming that most of the elements heavier than iron were produced by neutron star-neutron star mergers. Long considered a theoretical possibility, this is now a reality.

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, an L-shaped vacuum chamber, with two 4-km long arms joined at right angles, houses an optical interferometer. The interferometers are used to measure minute relative changes in the distances between the vertex of the L and mirrors at the ends of the arms that are caused by a passing gravitational wave. A passing gravitational wave causes the distance along one arm to lengthen while the other arm shrinks during one half cycle of the wave, and then the first arm shrinks while the other arm lengthens during the second half cycle. 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 amplitude of the length change over the 4-km length is only about 1/1000th the diameter of a proton. LIGO's 4-km length was chosen to make the expected signal as large as possible within terrestrial and financial constraints: Longer arms would result in a bigger signal but would entail larger construction costs. Looking for coincident signals from both interferometers increases LIGO's ability to discriminate a gravitational wave signal from local sources of noise that can mimic the signal.

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 greatly enhance LIGO's ability to locate gravitational wave sources on the sky, facilitating follow-up investigations using optical and radio telescopes. The scientific value of obtaining complementary gravitational wave and electromagnetic signals from the same source has already been demonstrated in the recent observation of a neutron star-neutron star merger. As the number of observations expands with enhanced sensitivity and localization, this will significantly increase our understanding of supernovae and neutron stars. Such scientific prospects help motivate the NSF Big Idea Windows on the Universe.

The Advanced LIGO upgrade, funded through the MREFC account, resulted in the design, fabrication, and installation of improved apparatus that is expected to increase LIGO's sensitivity 10-fold. LIGO's operating budget supported the initial commissioning of this apparatus. Following completion of installation of the Advanced LIGO apparatus in March 2015, LIGO scientists and engineers were able to achieve about four times LIGO's initial sensitivity by September 2015 in order to make the historic first detection of gravitational waves. Since then, after further commissioning, LIGO has been able to achieve more than a six-fold increase in sensitivity. Following the conclusion of the highly successful observing run that led to the discoveries discussed above, LIGO is now in the midst of a commissioning period that will lead to further enhancement of the sensitivity and more frequent detection possibilities.

Total Obligations for LIGO

(Dollars in Millions)

	FY 2017	FY 2018	FY 2019	**ESTIMATES**[1]				
	Actual	(TBD)	Request	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
Operations & Maintenance	$41.93	-	$45.00	$45.00	$45.00	$45.00	$45.00	$45.00

[1] Outyear funding estimates are for planning purposes only. The current cooperative agreement ends in September 2018.

LIGO is pursuing an integrated program of periodic scientific operation of the LIGO observatories, interleaved with engineering studies that continue to enhance operating performance. The operations budget also supports basic infrastructure maintenance, analysis, and dissemination of data obtained from the interferometers, and maintenance of computational resources for data storage and analysis. Operations funding also enables strategic research and development in instrument science that is expected to lead to longer-term enhancements to operational performance.

A small part of the operations budget supports education and outreach activities. The LIGO Science Education Center (LIGO SEC), located on the Livingston Observatory site, hosts 50 hands-on inquiry-based learning exhibits and reaches over 15,000 students, teachers and members of the public each year. Its activities benefit from a partnership with Southern University Baton Rouge (SUBR), the San Francisco Exploratorium, the Baton Rouge Area Foundation (BRAF), and other collaborating educational entities. Trained docents from SUBR assist participants and serve as collegiate-age role models for young visitors. LIGO SEC programs are supported both through LIGO's operations cooperative agreement and through grants to SUBR and BRAF. The LIGO Hanford Observatory also promotes a highly successful program of outreach to K-12 students and the general public in that region.

LIGO created a number of connections to industry in order to achieve the demanding technical performance requirements needed to detect gravitational waves. Innovations across a diverse range of technologies have led to new techniques with broad applications (for example, preparation of stainless steel for ultra-high vacuum application, adaptive laser beam shaping, and precision dielectric optical coatings). Other cases have resulted in patents and commercial products (in-vacuum electrical connectors, high power electro-optic modulators).

The LIGO Scientific Collaboration (LSC), an open collaboration that organizes the major international groups doing research supportive of LIGO, has more than 100 collaborating institutions in 18 countries with more than 1,200 participating scientists. The LSC plays a major role in many aspects of the LIGO effort. These include establishing priorities for scientific operation, data analysis and validation of scientific results, and contributing to instrumental improvements at the LIGO facilities, as well as fostering education and public outreach programs. NSF supports LSC activities in the U.S. at approximately $8.0 million per year, which is provided through regular disciplinary program funds.

In addition to the operations budget NSF also provides funds on an as-needed basis to handle critical infrastructure needs. These are awarded as supplemental funding contingent on the review and recommendation of a special expert review panel charged for that purpose. Such a review was held in May 2017 to respond to a need to address vacuum issues that threatened the integrity of the beam pipe. That review resulted in $2.50 million in supplemental funding in FY 2017.

NSF continually assesses the appropriate level of financial support by monitoring actual expenditures contained in quarterly activity-based financial reports from LIGO and through annual external reviews of operation.

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). The program director consults regularly with representatives from the NSF Large Facilities Office, the MPS Facilities Coordinator, and the NSF Division of Acquisition and Cooperative Support.
- 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 annual reviews.
- Recent Reviews: Reviews of observatory operation are held annually. Special purpose reviews using external expert panels have also been held as needed, examining topics such as long-term storage of the interferometer components set aside for possible deployment to India, LIGO computing plans, and LIGO ultra-high vacuum system needs. The last annual review was held in June 2017.

Renewal/Recompetition/Termination

LIGO began operating under a five-year cooperative agreement in early FY 2009, which ran concurrently with the Advanced LIGO MREFC project. 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, overlapping the conclusion of Advanced LIGO construction and the start of commissioning and scientific operation. NSF conducted a detailed consideration of whether or not to recompete the management of LIGO and determined that it would be in the best interest of U.S. science and engineering to renew the LIGO operating award at the end of FY 2018. Accordingly, NSF has requested and is in the process of reviewing a renewal proposal with the intent of submitting a request to the NSB in May 2018 for authorization to continue support. The projected lifetime of the LIGO facility was originally 20 years. Infrastructure refurbishments recently accomplished during the current award and planned for the new award will extend the facility life by an additional 15 to 20 years, to beyond 2030.

Installation of the green (532nm) Arm Length Stabilization (ALS) subsystem for AdvLIGO. *Credit: Caltech/MIT LIGO Laboratory*.

NATIONAL HIGH MAGNETIC FIELD LABORATORY (NHMFL) **$35,760,000**
+$12,610,000 / 54.5%

National High Magnetic Field Laboratory Funding[1]
(Dollars in Millions)

FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Percent
$23.15	-	$35.76	$12.61	54.5%

[1] Forward funding in FY 2016 reduced the amount needed in FY 2017 by $12.65 million. Without this action, the FY 2019 change over FY 2017 would be -$400,000, or -0.11 percent.

NHMFL is managed by Florida State University (FSU), and consists of facilities at FSU, the 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. There are approximately 1,500 users per year, including faculty and staff at the three host institutions. Stewardship and oversight of NHMFL is provided through the MPS Division of Materials Research (DMR), and the Fourier Transform Ion Cyclotron Resonance (FT-ICR) Laboratory is overseen by the MPS Division of Chemistry (CHE).

The laboratory is an internationally recognized leader in magnet design, development, and construction, including the development of new superconducting materials. Many unique magnet systems have been designed, developed, and built by the Magnet Science and Technology Division of NHMFL. Since 2012, the laboratory has held the world's record for the highest nondestructive, pulsed magnetic field at 100.75 Tesla, a unit of magnetic strength (magnetic flux density). The 45 Tesla magnet currently provides the highest steady-state magnetic fields in the world for user access. This world record has been held for more than a decade. Recently, NHMFL's new 36 Tesla Series-Connected Hybrid (SCH) magnet has reached its performance milestone of no change in magnetic field stability and homogeneity greater than 1 part per million (ppm) across the sampling volume. This stability has enabled the world's first nuclear magnetic resonance spectrum at 1.5 GHz which opens a window for chemists and biologists to probe greater numbers of elements in the periodic table. The field strength of this 36 Tesla magnet design exceeds those of other all-superconducting magnets by 62 percent, and those of all-resistive magnets with similar bore size and uniformity by 44 percent. Both the 45 Tesla and 36 Tesla magnets enable scientists to gain new insights into the electronic structures of novel materials such as graphene, topological insulators, and high temperature superconductors

In 2009, a $15.0 million award funded through CHE enabled the purchase of a 21 Tesla magnet for the construction of a FT-ICR spectrometer. The FT-ICR instrument opened for user operations in October 2015. This 21 Tesla FT-ICR is unprecedented in sensitivity and selectivity, capable of analyzing chemical samples of great complexity, such as biological fluids, biofuels, and raw and weathered petroleum. The system impacts a broad array of research areas, such as chemistry, molecular biology, and earth science.

A major scientific impact from NHMFL is expected from the research on quantum materials conducted by users using the record-setting NHMFL magnets. These magnets allow for the exhibition, identification, and visualization of new and unusual quantum effects that lead to deeper understanding of quantum materials and enables the discovery of new ones. 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 investigating other nuclei to use that would result in new insights into mapping the brain and neuroscience.

Total Obligations for NHMFL

(Dollars in Millions)

	2017	2018	2019	ESTIMATES[1]				
	Actual	(TBD)	Request	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
Operations & Maintenance (DMR)[2]	$23.15	-	$34.03	$35.05	$36.10	$37.18	$37.18	$37.18
Operations & Maintenance (CHE)[3]	-	-	1.73	1.73	1.73	1.73	1.73	1.73
Total	**$23.15**	-	**$35.76**	**$36.78**	**$37.83**	**$38.91**	**$38.91**	**$38.91**

[1] Outyear funding estimates are for planning purposes only. The new cooperative agreement is expected to end in mid-2023.

[2] DMR forward funded $10.73 million in FY 2016, thereby reducing the planned FY 2017 contribution to $23.15 million.

[3] CHE forward funded $1.92 million in FY 2016, thereby reducing the planned FY 2017 contribution to zero.

NHMFL collaborates with more than 60 private sector companies as well as national laboratories. These include those supported by the Department of Energy (DOE), such as Oak Ridge National Laboratory, which hosts the Spallation Neutron Source, and Argonne National Laboratory, which hosts the Advanced Photon Source. Additionally, NHMFL collaborates internationally. NHMFL delivered and commissioned a 26 Tesla SCH magnet to the Helmholtz-Zentrum Berlin for neutron scattering experiments. Collaborations also exist with the International Thermonuclear Experimental Reactor in France, and national magnet labs in France, the Netherlands, Germany, and China.

NHMFL provides a unique interdisciplinary and convergent learning environment. The Center for Integrating Research and Learning at NHMFL conducts education and outreach activities, which include a Research Experience for Undergraduates 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 DMR, with the DMR program director as the primary contact for most of the laboratory. CHE supports the 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 NHMFL executive committee, NHMFL science council, and NHMFL diversity committee and recommendations from an external advisory committee and the users' executive committee.
- 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*[17] was presented to the National Science Board (NSB) in May 2014. The report continues to inform future plans for investments in this area, including new magnet developments.
- In 2017, NSF held a workshop, *Exploring Quantum Phenomena and quantum Matter in Ultrahigh Magnetic Fields,* to identify the most exciting directions of ultrahigh-field research that could impact the understanding of quantum materials. This workshop was informed by the long-term ultrahigh field

[17] www.nap.edu/catalog/18355/high-magnetic-field-science-and-its-application-in-the-united-states

magnet development recommendations from the 2013 NRC report.

- 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. In addition to these yearly scientific reviews, NHMFL undergoes periodic business systems review by the NSF Large Facilities Office and the Division of Acquisition and Cooperative Support.
- Recent and upcoming reviews include:
  - Renewal proposal site visit, August 29-31, 2016.
  - NSF program director site visit, September 28, 2017.
  - Renewal of NHMFL approved by NSB, August 2017.
  - Site visit review with external panel of experts, October 2018.

Renewal/Recompetition/Termination

In May 2015, the NSB determined that it was in the best interest of the U.S. science and engineering enterprise to renew rather than re-compete the NHMFL award. A renewal proposal was submitted in May 2016. In August 2017, the NSB authorized an award to FSU for the operation of NHMFL for 60 months starting in mid-2018.

The National High Magnetic Field Laboratory, Tallahassee, Florida site. *Credit: NHMFL*

NATIONAL NANOTECHNOLOGY COORDINATED INFRASTRUCTURE (NNCI) **$14,780,000**
-$770,000 / -5.0%

National Nanotechnology Coordinated Infrastructure Funding
(Dollars in Millions)

FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Percent
$15.55	-	$14.78	-$0.77	-5.0%

The NNCI program was established in FY 2015 as the successor to the National Nanotechnology Infrastructure Network (NNIN). NNCI comprises 16 independent awards to universities around the Nation as user facility sites in nanotechnology. NNCI represents a model in which NSF selects and manages each university site in the network rather than a single lead institution with collaborating partners as in the previous NNIN, thus providing more flexibility in awardee selection and management, and more agility in addressing emerging user facility needs in nanoscale research and education. The 16 NNCI sites involve 29 universities and other partner organizations located in 17 states. The NNCI sites provide researchers in academia, small and large companies, and government with access to university user facilities with leading-edge fabrication and characterization tools, instrumentation, and expertise within all disciplines of nanoscale science, engineering and technology, thus helping to catalyze new discoveries in science and engineering and to stimulate technological innovation.

A Coordinating Office at the Georgia Institute of Technology was selected in FY 2016 through externally reviewed proposals from among the awarded sites to enhance the impact of NNCI as a national infrastructure network of user facility sites. The director of the Coordinating Office is a key individual for developing management strategies and operational plans in concert with the site directors of the individual user facilities, and serves as the principal contact person with NSF. The individual NNCI sites have autonomy in their operation and management but are required to act in concert with the Coordinating Office. The Coordinating Office has established a comprehensive web portal to ensure close linkage among the individual facility websites to present a unified face to the user community of overall tools, instruments, and capabilities.[18] It is harmonizing capabilities for modeling and simulation across sites and interaction with NanoHUB of the NSF-supported Network for Computational Nanotechnology (NCN). It is coordinating and disseminating best practices for national-level education and outreach programs, as well as instruction across sites in social and ethical implications of nanotechnology. It is establishing uniform methods for assessment and quantifiable metrics of site performance and impact; and is also engaging all sites in a planning process to explore emerging areas of nanoscale science, engineering, and technology that can lead to new research opportunities and future growth of the external user base.

The broad scope of NNCI sites coverage includes materials, structures, devices, and systems in areas of physics, chemistry, materials sciences, mechanical systems, geosciences, geophysical, geochemical, environmental sciences, biology, life sciences, synthetics biology, fabrication in soft matter including biological interfaces, biomedicine, electronics, optics, magnetics, molecular synthesis, molecular scale devices, manufacturing concepts, modeling and simulation, social and ethical implications of nanotechnology, and education and outreach. The individual award sites are intended to support a rich user base with broad accessibility and affordable user fee structure. NSF funds leverage those of university and other resources to grow the numbers of external users, including those from companies and academia. Sites 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 also have an organizational structure that facilitates coordination of complex process steps and tools for

[18] NNCI Coordinating Office web portal, www.NNCI.net

integrated tasks and acceptance of experimental risks associated with non-standard processes and materials.

Nanotechnology facilities provide unique opportunities to infuse innovative education with research at the frontiers of the field. Award sites are providing focused strategies for integrating pioneering 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 have integrated study and dissemination of those aspects into their activities that can leverage their user community base, which relate to the capabilities of their respective user facilities.

NNCI collects annual user data from October 1 to September 30 each year. In Year 1, the total number of unique users (internal and external) was 60,675, with 2,561 external users (23.9 percent). External users were composed of 1,151 academic users and 1,410 industry users (65 percent from small companies). There has been steady growth in these numbers. In Year 2, there were 12,447 total users, with 3,171 external users (25.5 percent). Year 2 external users include 1,504 academic and 1,667 industry users (61 percent from small companies). New (first time) users trained were 4,116 in Year 1 and 4,946 in Year 2.

Total Obligations for NNCI

(Dollars in Millions)

	FY 2017	FY 2018	FY 2019	**ESTIMATES**[1]				
	Actual	(TBD)	Request	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
Operations & Maintenance	$15.55	-	$14.78	$15.46	$15.46	$15.46	$15.46	$15.46

[1] Outyear funding estimates are for planning purposes only. The current cooperative agreement ends in FY 2019.

Management and Oversight

- NSF Structure: Post-award oversight is performed under the guidance of the NSF lead program officer and directorate working group members to monitor progress of the award and award accomplishments.
- External Structure: The NNCI Coordinating Office is led by a director, deputy director, and three associate directors who manage the network in specific areas: education and outreach programs, societal and ethical implications (SEI) activities, and computational activities and facilitates interactions with nanoHUB/NCN at Purdue University. The core staff is guided by an executive committee, which includes the 16 NNCI site directors. The NNCI Executive Committee meets monthly via teleconference/WebEx and annually in person at the NNCI Conference. The NNCI Executive Committee and Coordinating Office are advised by an external advisory board comprised of members representing industry, academia, government, education and outreach, SEI, computation and non-traditional disciplines in nanoscience and nanoengineering. Several subcommittees of the NNCI Executive Committee work to address high-level issues related to the NNCI network, such as new equipment and research opportunities, workforce development, diversity, and building the user base. An annual NNCI Conference organized by the NNCI Coordinating Office is held at different network sites to highlight the research supported by the NNCI facilities and to provide a venue to share best practices. The first of two annual NNCI Conferences was held at Georgia Tech in January 2017 covering FY 2016 activities and the second, covering FY 2017 activities, at the University of Pennsylvania in October 2017.
- Reviews: Reviews are being conducted through annual reverse site reviews at NSF. The awardees submit comprehensive annual project reports to NSF in advance of each annual review. The annual project reports contain a program plan and budget for the next year's funding increment. Each annual review of a site focuses on the quality of performance and management under the cooperative agreement. Data collection is consistent with NSF policies for information collection.

Renewal/Competition/Termination

The initial NNCI award is 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 Coordinating Office.

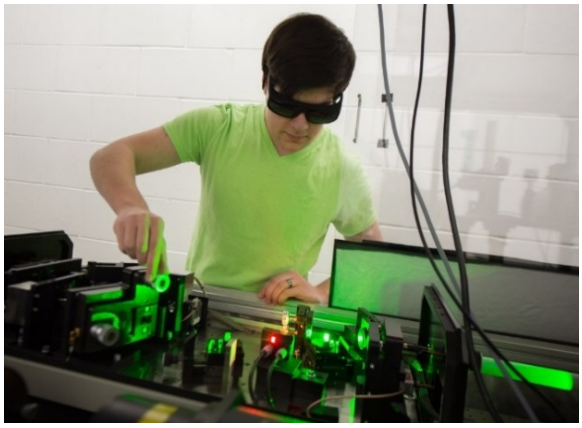
NATIONAL SUPERCONDUCTING CYCLOTRON LABORATORY (NSCL) **$24,000,000**
$0 / 0%

National Superconducting Cyclotron Laboratory Funding
(Dollars in Millions)

FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Percent
$24.00	-	$24.00	-	N/A

NSCL is a national user facility based at Michigan State University (MSU). With two linked superconducting cyclotrons, K500 and K1200, it is the leading rare isotope research facility in the U.S. and is a world leader in nuclear physics with the unique capability of producing radioactive beams at energies relevant to nuclear astrophysics. Funding for NSCL also supports the research program of the MSU nuclear science faculty.

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 studies on the effects of ionizing radiation on DNA, tests of detectors to be used in space missions, development of data acquisition systems and software, 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 operates an MSU-funded reaccelerator facility (ReA3) that enables experiments at very low energies—a domain of particular interest to nuclear astrophysics. NSCL is the only facility in the world to provide radioactive beams in this energy regime. Nearly one third of recently proposed experiments will use the ReA3. The mix of experiments is determined by proposals for beam use. 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 five to fifteen days.



Graduate student Andrew Miller aligning instrumentation on an optical table. *Credit: NSCL and MSU*

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 understanding 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.

Total Obligations for NSCL

(Dollars in Millions)

	FY 2017	FY 2018	FY 2019	ESTIMATES[1]				
	Actual	(TBD)	Request	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
Operations & Maintenance	$24.00	-	$24.00	$24.50	$24.50	-	-	-

[1] The current cooperative agreement ends in FY 2021, after which the NSF-managed NSCL will transition to the DOE-managed FRIB.

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 in the NSF Directorate for Mathematical and Physical Sciences, Division of Physics (MPS/PHY) and other staff, accompanied by external experts. The NSF program officer monitors lab operations and plans through monthly phone conferences with the NSCL director. NSF uses the annual site reviews to assess the user program, operations, maintenance, facility efficiency, national and international research developments, and in-house research programs. The program director consults regularly with the NSF Large Facilities Office, the MPS Facilities Coordinator, and the NSF Division of Acquisition and Cooperative Support.
- External Structure: MSU provides added support for NSCL, which is managed by a director and three associate directors (experimental research, education and outreach, and operations) as well as a chief scientist. 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 the chairperson of the NSCL user group. Opportunities for proposal submission occur once a year and the beam hour backlog is no longer than two years. Optimally the laboratory can provide about 5,000 beam hours to the scientific community each year, with actual output depending upon facility reliability factors and available funds.
- Reviews:
  - An in-depth review in FY 2016 looked at results and achievements related to intellectual merit and broader impacts for the past four years (FY 2012-FY 2015) as well as a review of proposed research, operations, and maintenance funding for the next five years (FY 2017-FY 2021).
  - The most recent annual review took place in April 2017. The report expressed overwhelming support for the management and operations of NSCL. The next review is planned for April 2018.

Renewal/Recompetition/Termination

NSCL currently operates under a cooperative agreement with MSU, which is due to expire in FY 2021. After that time NSCL will transition to the new Facility for Rare Isotope Beams (FRIB), which is being built by the Department of Energy (DOE) on the NSCL site. FRIB is scheduled to become operational in FY 2022 and will use much of the NSCL beamlines, instrumentation, and general infrastructure. NSF anticipates ending support for the operations component of NSCL when CCF operations cease so that FRIB can be integrated into the NSCL beamlines and FRIB become operational. MSU will be the performing institution under a cooperative agreement with DOE for the future FRIB. To facilitate interagency planning and coordinate the transition from the NSF-funded NSCL to the DOE-funded FRIB, a Joint Oversight Group (JOG) of DOE and NSF personnel has been meeting since 2010. DOE and NSF will coordinate transfer of facility stewardship as it transitions from NSCL to FRIB.

NATURAL HAZARDS ENGINEERING RESEARCH INFRASTRUCTURE (NHERI) **$11,750,000**
-$3,240,000 / -21.6%

Natural Hazards Engineering Research Infrastructure Funding
(Dollars in Millions)

FY 2017 Actual[1]	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Percent
$14.99	-	$11.75	-$3.24	-21.6%

[1] FY 2017 Actual includes $2.49 million in forward funding

The Natural Hazards Engineering Research Infrastructure program was established in 2015 by NSF as a distributed, multi-user, national research facility for use by the Nation's natural hazards engineering research community. NHERI facilities provide researchers access to large, shared, state-of-the-art facilities, unavailable through any other agency, to study the performance of civil infrastructure, including buildings, geostructures, and underground structures, to individual natural hazards, and to combinations of natural hazards. These facilities are essential research infrastructure to support two federally-mandated interagency programs: the National Earthquake Hazards Reduction Program and the National Windstorm Impact Reduction Program.

The portfolio of research investigations, which is funded separately through NSF's highly competitive, parallel proposal evaluation process, involves large scale experimentation linked to numerical modeling, and collection and sharing of data to increase the knowledge gleaned from investment in these facilities. Such research is essential to the development of more comprehensive and more realistic predictive models of how civil infrastructure responds to earthquake, wind, storm surge, and tsunami loading. These advances, in turn, enable the design of more hazard-resilient civil infrastructure and improved safety for citizens during these events.

The research infrastructure includes earthquake and wind engineering experimental facilities; a post-disaster, rapid response research (RAPID) facility; cyberinfrastructure; computational modeling and simulation tools; and a research data repository. The research infrastructure investment also supports education and community outreach activities.

During FY 2015 and FY 2016, NHERI was established by NSF through eleven cooperative agreements:

- Network Coordination Office (NCO) at Purdue University,
- Cyberinfrastructure (CI) at the University of Texas at Austin,
- Computational Modeling and Simulation Center (SimCenter) at the University of California, Berkeley,
- Twelve-Fan Wall of Wind at Florida International University,
- Large-Scale, Multi-Directional, Hybrid Simulation Testing Capabilities at Lehigh University,
- Large Wave Flume and Directional Wave Basin at Oregon State University,
- Geotechnical Centrifuges at the University of California, Davis,
- Large, High-Performance Outdoor Shake Table at the University of California, San Diego,
- Boundary Layer Wind Tunnel, Wind Load and Dynamic Flow Simulators, and Pressure Loading Actuators at the University of Florida,
- Large, Mobile Dynamic Shakers for Field Testing at the University of Texas at Austin, and
- RAPID Facility at the University of Washington.

The NCO serves as the national and international scientific leader, community focal point, and network-wide coordinator for NHERI governance and community-building activities. Key activities 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 user access to the experimental facilities, leading development of a community science plan, running NHERI-wide education and community outreach programs, and building strategic partnerships. NHERI awardees and the natural hazards engineering community 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 highly value-added and productive research infrastructure.

The CI awardee serves 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 (Data Depot); software service delivery platform with computational modeling, simulation, and educational tools (Discovery Workspace); collaboration tools; access to high performance computing resources; and user training and support. The CI awardee also establishes and implements the NHERI-wide cybersecurity plan with all NHERI awardees.

The SimCenter develops 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. The SimCenter's tools are integrated into the CI awardee's Discovery Workspace.

The experimental facilities provide well-maintained and fully-functioning facilities, services, and staffing to enable earthquake engineering, wind engineering, and post-disaster, rapid response research requiring experimental work and data collection. Data generated by these experimental resources and their users are archived and shared in the publicly accessible NHERI Data Depot.

Along with direct operations and maintenance support for NHERI awardees, NSF provides separate support for research to be conducted at the NEHRI experimental facilities through ongoing research and education programs. The support for such activities is primarily provided through the Engineering for Civil Infrastructure (ECI) core research program in the Civil, Mechanical and Manufacturing Innovation (CMMI) division in ENG.

Total Obligations for NHERI
(Dollars in Millions)

	FY 2017	FY 2018	FY 2019	**ESTIMATES**[1]				
	Actual	(TBD)	Request	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
Operations & Maintenance	$14.99	-	$11.75	$12.00	$12.00	$12.00	$12.00	$12.00

Outyear funding estimates are for planning purposes only. The current cooperative agreement ends in FY 2019.

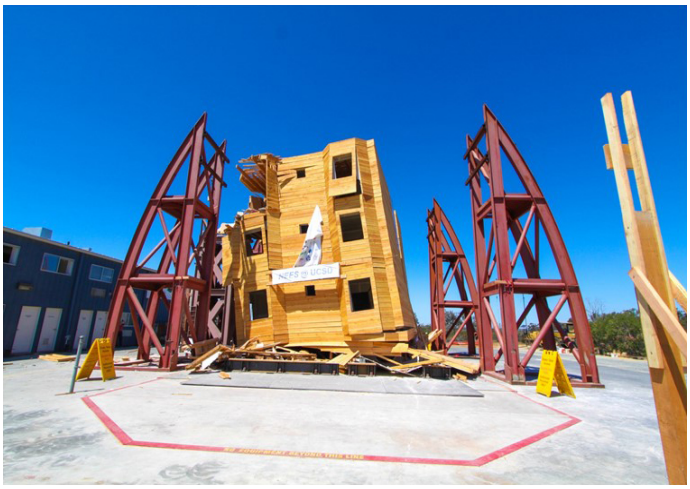
Management and Oversight

- NSF Structure: The NSF Program Officer for NHERI is located within ENG/CMMI. The Deputy Director of the Large Facilities Office in the Office of Budget, Finance, and Award Management provides advice and assistance.
- External Structure: Each NHERI awardee is led by a principal investigator (PI), who is responsible for the overall award operations. The NCO awardee coordinates NHERI governance and network activities. Governance is 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.

- Reviews: NSF provides oversight to NHERI awardees through cooperative agreements. Individual and joint awardee operations and activities are reviewed through quarterly and annual project reports submitted by awardees, and site visit reviews, as well as reverse site visit reviews, conducted by NSF program officers.

Renewal/Competition/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 (DCL) NSF 10-071.[19] One study, a workshop held by the National Research Council on the Grand Challenges in 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" Network for Earthquake Engineering Simulation (NEES) (NEES2) during FY 2015-2019 was presented to the National Science Board at their July 2012 meeting and described in DCL NSF 12-107.[20] The plan proposed 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, to allow larger investment in earthquake engineering research using NHERI facilities.



The above image displays the University of California, San Diego outdoor shake table, which allows large structures to be tested against seismic activity. Here, a wooden building shows damage after testing. *Credit: UCSD/Jacobs School of Engineering.*

- In 2012, the 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.[21]
- In February 2013, NSF released solicitation NSF 13-537 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.
- Based on the above studies and report, NSF established the plan for NHERI in FY 2014. This led to the release of solicitations NSF 14-605 and NSF 15-598 to establish NHERI through two competitions. Those competitions were completed in FY 2016. Awards for NHERI operations involve commitments for five years, contingent on available funds and satisfactory performance.
- During 2018 and 2019, ENG will develop a post-NHERI decadal science plan for natural hazards engineering research, education, and research infrastructure. NSF will use this decadal science plan as input for natural hazards engineering research infrastructure support beyond 2019.

[19] http://nsf.gov/pubs/2010/nsf10071/nsf10071.jsp
[20] www.nsf.gov/pubs/2012/nsf12107/nsf12107.jsp
[21] www.nist.gov/customcf/get_pdf.cfm?pub_id=915541

OCEAN OBSERVATORIES INITIATIVE (OOI) **$40,000,000**
+$39,660,000 / 11638.8%

Ocean Observatories Initative Funding
(Dollars in Millions)

FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Percent
$0.34	-	$40.00	$39.66	11639%

The Ocean Observatories Initiative began in FY 2009 as a MREFC construction project. In FY 2016, OOI transitioned from the MREFC construction effort to the management and operations phase and is now referred to as the OOI Program.

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 enables researchers to examine complex, interlinked physical, chemical, biological, and geological processes operating throughout the coastal regions and 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 provides the public, educators, students, and researchers with: (1) OOI long-term time series data sets (raw data and metadata are processed via conventional algorithms and quality control methods); (2) an in-situ ocean laboratory capability to allow OOI users to submit proposals for development and application of new technologies by connecting their instruments or concepts to the OOI network; and (3) OOI tools that will support undergraduate classroom applications of the OOI, as well as public outreach through informal education. Currently, the OOI delivers data/metadata and education tools to the public via the internet at www.oceanobservatories.org.

As originally conceived, the overarching scientific themes of the OOI spanned 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.

- *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.

Current Status

The OOI infrastructure is operating, transmitting ocean data to storage, and incrementally delivering processed datasets and data products via the website. Refurbishment and redeployments of the moorings, instruments, and platforms are planned and executed. Data quality management is maturing and the OOI science team is conducting outreach to the science community on the quality assurance/quality control (QA/QC) methods and procedures being used.

The FY 2017 budget of $340,000 reflected only the incremental support necessary to enable the potential transition of managing institutions associated with the competition for a new operation and management award of the OOI. Operating and managing the OOI currently costs $50.0 million annually, and was reduced to $44.0 million during the current recompetition expected to be completed by the end of FY 2018. In FY 2018, NSF decommissioned and removed the Global Array in the Argentine Basin. The Global Array in the Southern Ocean was partially removed and planning is ongoing with an international partner to complete the removal of the remaining components and reinstall the Surface Mooring at their cost in Fall 2018. Operations plans at the FY 2019 Request level of $40.0 million will be developed in partnership with the awardee and research community to maximize the scientific return of the facility.

Total Obligations for OOI
(Dollars in Millions)

	FY 2017	FY 2018	FY 2019	ESTIMATES				
	Actual	(TBD)	Request	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
Operations & Maintenance	$0.34	-	$40.00	$40.00	$40.00	$40.00	$40.00	$40.00

The Consortium for Ocean Leadership (COL) is the current awardee for OOI operations and maintenance. COL has major sub-awardees on the OOI program 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 currently operates the Coastal Endurance Array. Woods Hole Oceanographic Institution operates the Pioneer Coastal Array as well as the Global Arrays at the two remaining (in FY 2018) OOI global sites. Rutgers University currently manages the OOI data as well as the cyberinfrastructure and education and public outreach. Raytheon Corporation currently 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 GEO manages OOI operations located within the Integrative Programs Section. The oversight includes the review of observatory metrics and data quality management, as well as integration of the OOI with any new science or infrastructure proposals.

- External Structure: The OOI Program has a Science Oversight Committee (SOC) which provides input and guidance internally to COL for OOI infrastructure planning and management. In FY 2017, NSF established the nine member "Ocean Observatories Initiative Facility Board' (OOIFB) to provide input and guidance regarding the management and operation of the OOI. The OOIFB is independent of the SOC and held several formal meetings during FY 2017 and FY 2018.
- Reviews: In December 2017, NSF conducted a review of the OOI Glider Operations Program component. NSF is considering an Operations and Management review in calendar year 2018 before the planned closeout of the COL cooperative agreement in September 2018.

Operations Costs

Operations and Management in support of scientific research began in FY 2013 with the deployment of the first OOI instruments. The associated costs have been and will continue to be supported by OCE, with temporary support from the GEO's Division of Integrative and Collaborative Education and Research from FY 2015-2017. Support for research utilizing observatory data will be through the standard NSF proposal submission process to existing science 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 is producing regardless of the source of their support.

Education and Outreach

The OOI website and cyberinfrastructure provides an education portal to enable undergraduate level tools for education. The internal OOI SOC actively conducts outreach activities regarding the ocean science datasets to researchers, public, and education users.

Renewal/Recompetition/Termination

The OOI Operations and Management cooperative agreement with COL has been extended until September 30, 2018. A re-competition for the award was initiated in FY 2016 and is planned for completion by September 30, 2018.

POLAR FACILITIES AND LOGISTICS **$304,310,000**
-$28,960,000 / -8.7%

Polar Facilities and Logistics Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Percent
Polar Facilities[1]	$218.76	-	$193.98	-$24.78	-11.3%
Polar Logistics	114.51	-	110.33	-$4.18	-3.7%
Total	$333.27	-	$304.31	-$28.96	-8.7%

[1]Polar Facilities includes Concept and Development funding for AIMS.

Polar Facilities
OPP provides the infrastructure needed to support U.S. research conducted in Antarctica, including research funded by NSF and 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. 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), OPP supports the relay of real-time satellite-based weather information that informs global forecasting. In addition, OPP 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. OPP 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 South Pole Remote Earth Science and Seismological Observatory (SPRESSO), the most seismically-quiet station on earth and a key site contributing to U.S. activities associated with the Comprehensive Test Ban Treaty and to U.S. Geological Survey (USGS) and NSF efforts for global seismic monitoring; and access to sites that are key to precise orbit determinations for optimizing use of the Global Navigation Satellite System (GNSS).

Total Obligations for Polar Facilities
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	ESTIMATES FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
Antarctic Infrastructure & Logistics	$218.76	-	$193.98	$193.98	$193.98	$193.98	$193.98	$193.98

The FY 2019 Budget Request for Polar Facilities is $193.98 million.

OPP 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 returned to service in 2014 and is successfully providing annual icebreaking services for the McMurdo Station resupply effort.

Management and Oversight
- NSF Structure: OPP staff, including subject matter experts in operational and scientific disciplines, have overall responsibility for funding and managing Polar Facilities under the U.S. Antarctic Program

(USAP); NSF budgets for and manages USAP on behalf of the Nation. This includes planning all activities and overseeing contractors. OPP'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/on Antarctica and the Southern Ocean. Research is conducted in a broad array of geo- and bio- sciences, including earth system science, and space and astrophysical sciences. The Antarctic Infrastructure and 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 prime support contract is currently held by Leidos Innovations Corporation. There are many separate subcontractors for supplies and technical services, and other services are procured through separate competitively-bid contracts.
- Reviews: OPP 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 OPP and the Office of Budget, Finance, and Award Management (BFA). In addition, OPP's performance is reviewed externally by Committees of Visitors and the Office of Polar Programs Advisory Committee. The USAP Blue Ribbon Panel (BRP) released a report on its review of the program in July 2012.[22] The NSF response to the USAP BRP report was released in March 2013.[23]

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.
    - For example, plans are under development to upgrade satellite communications systems to support operations and research and to replace the Palmer Station pier to ensure long-term access to unique research in the peninsula region.
    - The Antarctic Infrastructure Modernization for Science (AIMS) project is currently moving toward the final stages of design. FY 2019 funds will be used to complete the designs of all construction components, begin the site preparation work for the backbone utilities and the initial buildings such as the Vehicle and Equipment Operations Center, and procure the first phases of construction materials. The AIMS project will redevelop McMurdo Station to be a consolidated, cost effective facility, including modernized utilities distribution and fire protection. For additional information on AIMS see the OPP narrative.

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 eight

[22] www.nsf.gov/od/opp/usap_special_review/usap_brp/rpt/index.jsp
[23] www.nsf.gov/od/opp/usap_special_review/usap_brp/rpt/nsf_brp_response.pdf

and a half years. Leidos Innovations Corporation now holds the contract as it acquired the responsible division of Lockheed Martin in 2016.

- Contracts for fixed and rotary wing support are managed as assisted acquisitions by the Department of Interior, Office of Aviation Services. A five-year contract for helicopter support was awarded to PHI, Inc. of Lafayette, Louisiana. A five-year contract for fixed-wing aviation services, currently held by Kenn Borek Air of Calgary, Canada, is now under competition.
- 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 2017	FY 2018	FY 2019	ESTIMATES				
	Actual	(TBD)	Request	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
U.S. Antarctic Logistical Support	$69.28	-	$71.00	$71.00	$71.00	$71.00	$71.00	$71.00
Arctic Research Support & Logistics	45.06	-	39.33	39.33	39.33	39.33	39.33	39.33
Total	**$114.34**	**-**	**$110.33**	**$110.33**	**$110.33**	**$110.33**	**$110.33**	**$110.33**

The FY 2019 Budget Request for Polar Logistics is $110.33 million.

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 through the Space and Naval Warfare Systems Command; 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 OPP 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; assets 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: OPP 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. In December 2017, CH2M Hill was acquired as a wholly owned subsidiary by Jabob's Engineering. There are many separate subcontractors for supplies and technical services, and other services are procured through separate competitively bid contracts.
- Reviews: OPP 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 OPP and BFA. OPP's performance is externally reviewed by Committees of Visitors and the Office of Polar Programs Advisory Committee.

Current Status

All facilities (stations, research vessels, and field camps) are currently operating as normal.

Renewal/Recompetition/Termination

NSF re-competed 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. Preparations are underway for a Federal Acquisition Regulation -based competition to ensure a smooth transition in 2020 to a new contract.

SEISMOLOGICAL FACILITIES FOR THE ADVANCEMENT OF GEOSCIENCE AND EARTHSCOPE (SAGE) **$24,160,000**
-$1,040,000 / -4.1%

Seismological Facilities for the Advancement of Geosciences and Earthscope Funding

(Dollars in Millions)

FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Percent
$25.20	-	$24.16	-$1.04	-4.1%

The Seismological Facilities for the Advancement of Geoscience and EarthScope 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 125 U.S. universities and non-profit institutions with research and teaching programs in seismology, 21 educational affiliates, three U.S. affiliates, and 128 foreign affiliates. SAGE was formed in late FY 2013 from the seismic components of the EarthScope facility and seismic facilities previously managed by IRIS. The FY 2019 Budget Request will enable SAGE to provide key services for the geoscience research community, including global and regional observing networks, field and technical support for experiments worldwide, data management and distribution systems, and other related activities.

Total Obligations for SAGE

(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	ESTIMATES FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
Operations & Maintenance	$25.20	-	$24.16	$24.16	$24.16	$24.16	$24.16	$24.16

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 of the Earth. To serve the research needs of the broad Earth science community, SAGE is organized under three primary service 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. GSN stations provide critical data for a range of global Earth science research, and support key national security needs such as nuclear test-ban treaty verification and natural hazards warning and response. GSN is operated in partnership with the U.S. Geological Survey (USGS).
- 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 to study a wide range of Earth processes.
- 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.
- 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. Over 1,700 TA stations operated across the lower 48 states and southern Ontario and Quebec, Canada,

between 2004 and 2015. The full 280-station TA network is now deployed in Alaska and western Canada. These stations collect data for use in studies of natural hazards including earthquakes, volcanoes, and tsunami; the plate tectonic process that have formed Alaska; Earth's magnetic field; and Earth's changing climate.

- 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.
- 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 450 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. In the last quarter of FY 2017, more than 20,000 unique users downloaded over 136 TB of data from the SAGE archive. These data enable the wide range of Earth science studies described above.

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.

Besides its role in providing the observational data essential for basic Earth science research, SAGE supports community activities including scientific and technical workshops that bring together the international seismic community and publications designed to communicate SAGE activities and results to the community. SAGE also provides real-time seismic data to the USGS and the National Oceanic and Atmospheric Administration (NOAA) for global earthquake, volcano, and tsunami monitoring, and enables international seismic monitoring of compliance with the Comprehensive Test Ban Treaty.

SAGE is heavily involved in partnership activities, many international in nature. Because GSN stations are hosted by a variety of local organizations, installation and operation of the GSN has put IRIS in contact with scientists, as well as governmental 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. For all these purposes, Federal 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 OPP provide most of the funds, totaling approximately $15.0 million annually, for NSF-sponsored research making use of SAGE. Funds permit deployment of portable seismic instruments and use of data managed by DS to solve major Earth science problems.

Management and Oversight

- NSF Structure: The Division of Earth Sciences (EAR) in the Directorate for Geosciences, 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. The EAR Division Director and Integrated Activities Section Head provide other internal oversight.

- External Structure: SAGE is managed and operated by IRIS, which is incorporated as a non-profit consortium representing 125 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 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. 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. In 2015, an external review of the GSN component of SAGE found that management of GSN by IRIS has been exemplary.

Renewal/Recompetition/Termination

Funding for the SAGE cooperative agreement began in FY 2014 and ends in FY 2018. In FY 2016, in keeping with the phased integration and recompetition plan presented to the National Science Board in December 2009, NSF solicited proposals to manage and operate one or more components of a new facility to support the Earth sciences research and education community. These components are currently supported by SAGE and the related Geodesy Advancing Geosciences and EarthScope facility. The new distributed, multi-user, national facility would support the development, deployment, management, and operational support of modern geodetic, seismic, and related geophysical instrumentation and provide services to serve national goals in basic research and education in the Earth sciences. As part of a robust re-competition and cost review process, various NSF oversight activities have been completed and others are currently underway, such as an independent cost assessments to inform NSF's cost analysis for a potential award.

FEDERALLY FUNDED RESEARCH AND DEVELOPMENT CENTERS (FFRDCS)

NATIONAL CENTER FOR ATMOSPHERIC RESEARCH (NCAR) **$94,700,000**
-$5,000,000 / -5.1%

National Center for Atmospheric Research Funding
(Dollars in Millions)

FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Percent
$99.70	-	$94.70	-$5.00	-5.1%

NCAR is an NSF-sponsored FFRDC serving a broad research community, including atmospheric and geospace scientists and researchers in complementary areas of the environmental sciences and geosciences. Based in Boulder, Colorado, 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 117 degree-granting academic institutions.

As of September 2017, NCAR supported a total of 724.9 full time equivalents (FTEs), of which 327.6 are funded under the NSF primary award to UCAR.

Number of FTEs Supported at NCAR

FTEs	Primary Award[1]	All Funding
Career Scientists	69.9	100.6
Scientific Support[2]	227.2	501.0
Other Staff[3]	30.5	123.3
Total	**327.6**	**724.9**

[1] The primary award also includes funding for non-staff costs, such as infrastructure.

[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, and mechanics.

NCAR provides world-class research programs, services, and facilities that enable the research community to advance our understanding of the sun-atmosphere system. These include the NCAR-Wyoming Supercomputing Center, the Mauna Loa Solar Observatory, two research aircraft, a transportable ground-based radar system, an atmospheric sounder, and other surface sensing systems.

Total Obligations for NCAR

(Dollars in Millions)

	FY 2017	FY 2018	FY 2019	ESTIMATES				
	Actual	(TBD)	Request	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
Aircraft Support	$10.07	-	$9.33	$9.33	$9.33	$9.33	$9.33	$9.33
Computational Infrastructure	32.38	-	30.03	30.03	30.03	30.03	30.03	30.03
Other Facility Support	26.55	-	24.47	24.47	24.47	24.47	24.47	24.47
Research & Education Support	30.70	-	30.87	30.87	30.87	30.87	30.87	30.87
Total	**$99.70**	**-**	**$94.70**	**$94.70**	**$94.70**	**$94.70**	**$94.70**	**$94.70**

Partnerships and Other Funding Sources: NCAR leverages NSF support with funding provided by other federal agencies and non-federal sources. In FY 2017, NCAR received approximately $38.30 million in support from other federal agencies, including the National Oceanic and Atmospheric Administration, the Department of Energy, and the Federal Aviation Administration, and $20.0 million from non-federal sources. This funding supports research collaboration that enhance NCAR's NSF-supported research goals or facilities missions.

Major Investments in FY 2019: In FY 2019, 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, better understanding of the structure and nature of hurricanes and other severe weather events, and the impacts of processes on the surface of the Sun on space weather and weather on Earth. A continuous process of community prioritization will inform activities undertaken in FY 2019.

Aircraft Support: NCAR operates two NSF aircraft: a C-130Q Hercules and a Gulfstream-V (the 'G-V'), 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 community-originated projects deemed by peer review to be of exceptional scientific merit, consistent with the research prioritization mentioned above.

Computational Infrastructure: NCAR operates a petascale supercomputing facility in Cheyenne, Wyoming (the NCAR-Wyoming Supercomputing Center), that supports high-end community modeling programs in atmospheric, solar, and other Earth Systems processes. These include the Community Earth System Model (CESM), the Weather Research and Forecasting Models (WRF), and the Model for Prediction Across Scales (MPAS), 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 and solar observing platforms through its Earth Observing Laboratory (EOL) and High Altitude Observatory (HAO), including specialized Doppler weather radars, lidar systems, upper atmosphere observing capabilities, an advanced coronagraph, and other experimental systems.

Research and Education Support: 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 Earth System processes;
- 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 the interaction of the solar wind 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 atmospheric composition, weather, and climate, and response to global environmental change.

Research collaborations with university colleagues are integral to NCAR's success as an institution, and NCAR serves as a focal 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 information and analysis platforms tailored to the specific needs of stakeholders in a variety of sectors, including energy, aviation, and agriculture.

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. 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, 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) within GEO and the Division of Acquisition and Cooperative Support (DACS) oversee NCAR and the cooperative agreement under which UCAR manages NCAR. The cooperative agreement encourages interactions between NCAR scientists and AGS staff and ensures close coordination between AGS and NCAR management. The cooperative agreement contains requirements for AGS's oversight of the NCAR program and UCAR management activities that affect NCAR. UCAR submits for AGS approval an annual program plan for NCAR that details how resources will be used, and an annual report on the previous year's scientific accomplishments and achievements. UCAR also reports annually to NSF on its activities as NCAR's manager. Annual strategic planning between AGS, UCAR, and NCAR ensures that scientific and facility priorities align with those of NSF.
- External Structure: UCAR works in partnership with NSF and the university community to ensure that NCAR's strategic mission is implemented effectively and for the benefit of NCAR's stakeholders in the atmospheric and geospace sciences
- Reviews: A Committee of Visitors (COVs) is convened periodically to evaluate AGS oversight of NCAR. The most recent COV was conducted in FY 2015, with the next anticipated in FY 2019. A Business Systems Review was conducted in FY 2011 and examined UCAR administrative business systems. No significant issues were raised in either of the most recent reviews.

Renewal/Recompetition/Termination

In 2016, AGS conducted a comprehensive review of NCAR's science programs and facilities, and UCAR's management of NCAR. The review was conducted as a series of site visits to NCAR by teams comprising members of the research community with expertise in the atmospheric and related sciences and in the management of scientific centers and facilities. The site visit teams found that NCAR continues to be a world-leading research center, providing essential services and capabilities that foster excellence throughout the atmospheric and geospace sciences community.

The cooperative agreement for management and operation of NCAR is currently being recompeted, with the next award expected to be for the five years beginning in FY 2019. As part of a robust re-competition and cost review process, various NSF oversight activities have been completed and others are underway, such as independent cost assessments to inform NSF's cost analysis for a potential award.

The NCAR Mesa Laboratory, designed by architect I.M. Pei, in Boulder, CO. *Credit: UCAR.*

NATIONAL OPTICAL ASTRONOMY OBSERVATORY (NOAO) **$20,130,000**
-$2,860,000 / -12.4%

National Optical Astronomy Observatory Funding
(Dollars in Millions)

FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change Over FY 2017 Actual Amount	Change Over FY 2017 Actual Percent
$22.99	-	$20.13	-$2.86	-12.4%

NOAO was established in 1984 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 ground-based optical and infrared (OIR) astronomy to coordinate, integrate, and operate observational, technical, and data-oriented capabilities available throughout the U.S. OIR system of federal and non-federal assets.

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. NOAO 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 Gemini Observatory through the U.S. National Gemini Office. NOAO coordinates community access to telescopes throughout the U.S. OIR system, and it facilitates connecting the scientific user to data archives by developing and maintaining data management capabilities. NOAO integrates community planning for future facilities and instrumentation projects under a national organization. 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 facilities, telescopes, and data systems, are open to all qualified astronomers regardless of institutional affiliation. 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 facilities for research projects. In FY 2017, NOAO employed 300 personnel in Arizona and Chile, including 45 support scientists and 10 postdoctoral fellows.

Total Obligations for NOAO
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	ESTIMATES[1] FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
NOAO Base O&M	$19.19	-	$19.13	$19.70	$20.29	$20.90	$21.53	$22.18
Tucson Operations	*9.92*	-	*9.30*	*9.58*	*9.86*	*10.16*	*10.46*	*10.78*
Chilean Operations	*8.24*	-	*8.74*	*9.00*	*9.27*	*9.55*	*9.84*	*10.14*
Kitt Peak Operations	*1.03*	-	*1.09*	*1.12*	*1.16*	*1.19*	*1.23*	*1.26*
Special Projects: WIYN, Mayall	3.80	-	1.00	1.00	1.00	1.00	1.00	1.00
Total	**$22.99**	-	**$20.13**	**$20.70**	**$21.29**	**$21.90**	**$22.53**	**$23.18**

[1] The current cooperative agreement ends in September 2020.

Partnerships and Other Funding Sources: The managing organization for NOAO is the Association of Universities for Research in Astronomy, Inc. (AURA), which is comprised of 44 U.S. member institutions

and four 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 2013 on the CTIO 4-meter Blanco telescope, and is now scheduled for a one year extension, due to poor weather conditions at the observing site in Chile. The extended survey is expected to end in February 2019.

NOAO is a partner in the 4.1-meter SOuthern Astrophysical Research (SOAR) telescope at CTIO. SOAR partners include the University of North Carolina, Chapel Hill; Michigan State University; and the Ministério da Ciência, Tecnologia, Inovações e Comuniçaões do Brasil.

Another partnership with DOE involves installation of the Dark Energy Spectroscopic Instrument on the Mayall telescope on Kitt Peak in February 2018 for a five-year dark energy science program. In FY 2019, DOE is scheduled to fully assume Mayall operations funding.

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 program. NOAO has a diverse education program, visitor centers, and a web-based information portal at www.noao.edu.

NOAO Base O&M: $19.13 million, $60,000 below the FY 2017 actual.

- Tucson Operations: $9.30 million, $620,000 below the FY 2017 Actual: This covers the cost for headquarters, offices, laboratories, and workshops in Tucson, Arizona.

- Chilean Operations: $8.74 million, $500,000 above the FY 2017 Actual: This supports the administration office and labs in La Serena, Chile and mountain operations on Cerro Tololo and Cerro Pachón.

- Kitt Peak Operations: $1.09 million, $60,000 above the FY 2017 Actual: This funds basic infrastructure for all facilities on the mountain, which are accounted as tenants.

Special Projects (Wisconsin, Indiana, Yale, NOAO consortium (WIYN) and Mayall): $1.0 million, $2.80 million below the FY 2017 Actual: This decrease is due to Mayall operations being fully supported by the DOE in FY 2019.

Potential Future Projects - Data Science Support: NOAO currently provides data scientific support for U.S. community observations with the Gemini telescopes. In addition, proposals are under consideration for NOAO to maintain an ongoing management role for Gemini and LSST operations through the scope of its Federally Funded Research and Development Center. Potential future funding (FY 2020 and beyond) would provide the option for a modern management structure for U.S. Optical/IR nighttime telescope assets

without reducing commitments to flagship facilities.

Management and Oversight

- NSF Structure: An NSF program officer in the MPS Division of Astronomoical Sciences (AST) provides continuing oversight, including consultation with an NSF panel of external program reviewers that meets once 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 NSF 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 NSF cooperative agreement that began in FY 2016. AURA receives management advice from an observatory council composed of members of its scientific and management communities. NOAO uses a Users' Committee, comprised of community scientists, to advise the NOAO director on all aspects of user experiences at the Observatory.
- Reviews: In addition to reviews midway through all cooperative agreements, NSF conducts both periodic and ad hoc external reviews of AURA management. A comprehensive review of AURA's performance is planned for FY 2019, the fourth year of the five-year cooperative agreement.

Renewal/Recompetition/Termination

The last competition for management and operation of NOAO was completed with the issuance of a new cooperative agreement with AURA starting October 1, 2015 and ending September 30, 2020.

NATIONAL RADIO ASTRONOMY OBSERVATORY (NRAO) **$79,130,000**
+$2,470,000 / 3.2%

National Radio Astronomy Observatory Funding
(Dollars in Millions)

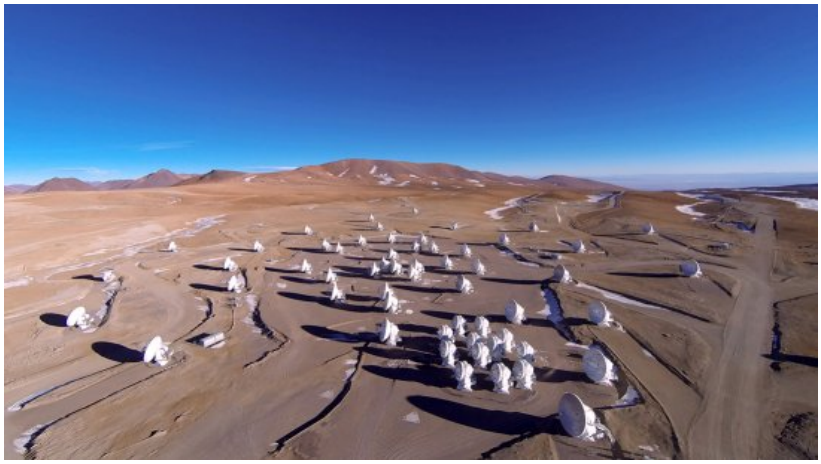
FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Change over FY 2017 Actual Percent
$76.66	-	$79.13	$2.47	3.2%

This table aggregates funding requested for NRAO and ALMA base operations.

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, x-ray, and gravitational wave 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 the sources of gravitational waves.

As a Federally Funded Research and Development Center headquartered in Charlottesville, Virginia, NRAO operates the Karl G. Jansky Very Large Array (VLA) near Socorro, New Mexico and 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 2,500 users worldwide; moreover, continuing high 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, staff in FY 2019 will consist of 296 full-time equivalent positions (FTEs) in the operations and maintenance components: 114 in telescope operations, 56 in science support and research, 35 in development programs, 51 in computing and data management, 21 in administrative services, and 19 in education and public outreach. These numbers exclude staff at the partitioned Green Bank Observatory and Long Baseline Observatory, managed and operated separately from



ALMA is in science operations following the completion of construction in 2015. An international partnership between North America, Europe, and East Asia, ALMA provides orders-of-magnitude improvement in observing sensitivity and image quality over previous facilities. *Credit: NRAO/AUI.*

NRAO, as well as 86 staff in the NRAO common cost pool that serve multiple observatories. In addition, the NRAO managing organization, Associated Universities, Inc. (AUI), employs local ALMA operations staff in Chile, currently about 254 FTEs.

Total Obligations for NRAO

(Dollars in Millions)

	FY 2017	FY 2018	FY 2019	**ESTIMATES**[1]				
	Actual	(TBD)	Request	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
Operations & Maintenance	$31.67	-	$38.85	$34.97	$36.02	$37.10	$38.22	$36.36
Telescope Operations	*10.63*	-	*10.99*	*10.92*	*11.25*	*11.59*	*11.94*	*10.82*
Development	*3.26*	-	*8.02*	*4.56*	*4.70*	*4.84*	*4.99*	*4.52*
Science Operations	*6.00*	-	*6.17*	*6.59*	*6.79*	*6.99*	*7.20*	*6.51*
Administrative Services	*9.15*	-	*10.49*	*10.04*	*10.33*	*10.64*	*10.96*	*11.29*
Directors Office	*1.99*	-	*2.42*	*2.16*	*2.23*	*2.30*	*2.36*	*2.43*
Education and Public Outreach	*0.64*	-	*0.76*	*0.70*	*0.72*	*0.74*	*0.77*	*0.79*
ALMA Operations	44.98	-	40.28	47.26	48.68	50.14	51.64	56.19
Total	**$76.66**	**-**	**$79.13**	**$82.23**	**$84.70**	**$87.24**	**$89.86**	**$92.55**

[1] Outyear funding estimates are for planning purposes only. The current cooperative agreement ends in FY 2026.

The total FY 2019 NRAO Budget Request includes ALMA operations ($40.28 million) and non-ALMA operations and maintenance ($38.85 million). The ALMA request provides for continued ALMA operations and is below the previously planned request due to the favorable exchange rate, lower fuel prices in Chile, and contributions from international partners.

Partnerships and Other Funding Sources: NRAO supplements NSF Division of Astronomical Sciences (AST) support with funding provided by other NSF sources, other federal agencies, and non-federal sources. In FY 2017, NRAO received approximately $100,000 from non-AST sources at NSF, $1.20 million from other federal agencies, and $1.20 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 hardware and software companies.

Telescope operations, $10.99 million: This encompasses support for direct telescope and array operations of the VLA including maintenance, infrastructure upgrades, and telescope management.

Development, $8.02 million: The FY 2019 Budget Request continues to support development programs including next generation electronics and detectors for radio astronomy, as well as planning and the development of technologies for a next-generation centimeter wavelength facility (next generation Very Large Array, or ngVLA).

Science operations, $6.17 million: This includes telescope time allocation, staff research, science training and education, and science community outreach.

Administrative services, $10.49 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, $2.42 million: This supports the director's office and managing organization costs.

Education and Public Outreach, $760,000: NRAO supports a comprehensive outreach program that makes radio astronomy information available to the public.[24] With over 150 students involved per year, NRAO facilities are used by graduate students carrying out dissertation research and work experience programs and by undergraduates participating in the Research Experiences for Undergraduates program. NRAO also supports a visitor and education center and conducts active educational and public outreach programs. The VLA visitor center attracts over 20,000 public visitors each year.

ALMA Operations, $40.28 million: In FY 2015, NRAO completed construction of the international ALMA Observatory, funded through the MREFC account. Early operations funding for ALMA began in FY 2005 and ramps up to steady state operations in FY 2018. Operations funding supports a share of observatory operations in Chile, a technical development program, and the North American ALMA Science Center (NAASC). NRAO created the NAASC in 2006 to provide technical and scientific support for, and easy access by, the broad astronomical community that uses ALMA. The NAASC also organizes summer schools, workshops, and courses in techniques of millimeter and submillimeter astronomy.

Management and Oversight

- NSF Structure: In consultation with community representatives, an AST program officer carries 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. This program officer participates in the international ALMA Board and attends AUI/NRAO governance and advisory committee meetings. To address issues as they arise, AST works closely with other NSF offices, such as the Office of General Counsel, the Office of International Science and Engineering, the Division of Acquisition and Cooperative Support, and the Large Facilities Office in BFA.
- External Structure: Management is through a cooperative agreement with AUI, which manages the observatory through its own community-based oversight and users committees. The NRAO director reports to the AUI president. 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 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 operations, and the AUI Management Report.

Renewal/Recompetition/Termination

Following a solicitation issued in FY 2014 (NSF 14-568), management and operation of NRAO, including ALMA, was competed and NSB authorized a cooperative agreement with AUI for October 1, 2016 through September 30, 2026.

[24] https://public.nrao.edu/

NATIONAL SOLAR OBSERVATORY (NSO) **$20,500,000**
+$3,000,000 / 17.1%

National Solar Observatory Funding
(Dollars in Millions)

			Change over FY 2017 Request	
FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Amount	Percent
$17.50	-	$20.50	$3.00	17.1%

FY 2019 marks the final year 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), the construction of which is nearing completion. (See the MREFC chapter for more information). This budget request will fund the development of the DKIST science operations and data center concepts in preparation for full DKIST operations expected to begin in late 2019-early 2020. The FY 2019 Budget Request fully funds the DKIST operations requirement and the NSO Integrated Synoptic Program (NISP).

As a Federally Funded Research and Development Center (FFRDC), NSO is headquartered on the campus of the University of Colorado, Boulder and provides leadership to the solar community through management of the construction of DKIST. When completed, DKIST will be the world most powerful solar observatory. Life on Earth is critically dependent upon the Sun. Solar phenomena such as space weather (e.g. geomagnetic storms) can significantly impact our increasingly technological society. DKIST will investigate the structure and evolution of magnetic structures on the Sun on spatial scales of tens of kilometers, the fundamental length scales of the processes that drive space weather. With DKIST poised to answer fundamental questions in solar physics by providing transformative improvements over current ground-based facilities, solar research enabled by DKIST will benefit all of humankind. NSO also operates a coordinated worldwide network of six telescopes specifically designed to study solar oscillations. NSO routinely provides 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.

NSO telescopes are open to all astronomers regardless of institutional affiliation based on peer-reviewed observing proposals. In FY 2017, 27 unique observing programs from 18 U.S. and seven foreign institutions were carried out using NSO facilities. This is a reduction from previous years as NSO ramps down its involvement in Sacramento Peak and the McMath-Pierce Solar Telescope. Students were part of 14 percent of these programs, which included three Ph.D. thesis projects. Nearly 12 terabytes of NSO synoptic data were downloaded from the NSO Digital Library. NSO employed approximately 138 staff members in FY 2017, including 59 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*,[25] 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 MPS Division of Astronomical Sciences (AST) conducted a community-based review of its portfolio. The resulting Portfolio Review

[25] www.nap.edu/catalog.php?record_id=12951

Committee (PRC) report, *Advancing Astronomy in the Coming Decade: Opportunities and Challenges*,[26] 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) at Sacramento Peak through 2017 and a 50 percent reduction in funding of the NSO Integrated Synoptic Program (NISP). The status of the divestment of NSO operated facilities is as follows:

- *McMath-Pierce Solar Telescope, Kitt Peak, AZ*: NSO ceased operating the McMath-Pierce Solar Telescope as a national user facility at the end of FY 2017. NSF completed a divestment options study of NSO facilities on Kitt Peak and anticipates beginning an environmental impact analysis process in FY 2018, consistent with the National Environmental Policy Act. On March 31, 2017, NSO/Association of Universities for Research in Astronomy (AURA) issued a request for proposals from parties interested in taking over operation of the McMath-Pierce Solar Telescope for scientific and educational purposes, but received no viable proposals. The path forward for the McMath-Pierce is currently under discussion.
- *Sacramento Peak Observatory, Sunspot, NM*: This facility includes the DST and associated infrastructure including office space, laboratory space, dining facilities, and housing. NSO ceased operating Sacramento Peak Observatory as a national user facility at the end of FY 2017. A proposal from New Mexico State University (NMSU) to transition operations of the facility from NSO to an NMSU-led consortium was funded in FY 2016. As discussions on the future of Sacramento Peak continue with NMSU, in parallel NSF began the preparation of an Environmental Impact Statement (EIS) in late 2016, which is examining a range of paths for Sacramento Peak Observatory. Fully compliant with the National Environmental Policy Act, the final EIS is expected in late 2018.
- *NSO Integrated Synoptic Program*: NISP consists of the Global Oscillations Network Group (GONG) and the Synoptic Optical Long-term Investigations of the Sun (SOLIS). GONG now has a component of its operations funding provided through a 5-year (FY 2016 – FY 2020) interagency agreement with the National Oceanic and Atmospheric Administration (NOAA). This NOAA funding supports the use of GONG and its data products for operational space weather forecasting. (Also see Partnerships section below). NSO is in the process of relocating the SOLIS facility to the Big Bear Solar Observatory (BBSO) on Big Bear Lake, CA. On September 29, 2017, NSO received a permit from San Bernardino County to install SOLIS on the site. Shortly thereafter, NSF's Record of Environmental Compliance was signed on October 2, 2017 allowing the project to move forward.

Total Obligations for NSO

(Dollars in Millions)

	FY 2017	FY 2018	FY 2019	**ESTIMATES**[1]				
	Actual	(TBD)	Request	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
NSO Base Operations	$5.74	-	$3.70	$3.82	$3.92	$4.04	$4.16	$4.29
NSO Education & Public Outreach	0.26	-	0.30	0.31	0.32	0.33	0.34	0.35
DKIST Operations[2]	11.50	-	16.50	17.01	17.54	18.08	19.13	19.71
Total	**$17.50**	**-**	**$20.50**	**$21.14**	**$21.78**	**$22.45**	**$23.63**	**$24.35**

[1] Outyear funding estimates are for planning purposes only. The current cooperative agreement ends September 2024.

[2] Excludes funding for cultural mitigation activities as agreed to during the compliance process. See the MREFC chapter for more information on DKIST.

[26] www.nsf.gov/mps/ast/ast_portfolio_review.jsp

Partnerships and Other Funding Sources: The managing organization for NSO is AURA, which comprises 44 U.S. member institutions and four international affiliate members. NSO partners include NOAA, NASA, industrial entities, and universities and institutes that collaborate with NSO on solar instrumentation development. NSF is currently under discussions with New Mexico State University (NMSU) regarding future operations of Sacramento Peak Observatory and New Jersey Institute of Technology (NJIT) on future operations of SOLIS at BBSO.

Due to the increasing national and international awareness of the impacts of space weather on critical infrastructure and society in general, the importance of operational space weather forecasting has become 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. NSO's GONG program provides operational data products on a routine basis that are used as inputs to predictive space weather models from the U.S. Air Force and the NOAA Space Weather Prediction Center. FY 2016 support for NSO included a one-time $2.50 million investment in GONG to increase its robustness for future space weather predictions. NSO is in the process of upgrading the GONG facility with this funding, with completion expected in FY 2018. In FY 2016, NSF and NOAA signed an interagency agreement whereby NOAA is providing approximately $800,000 per year in funding support for GONG operations.

NSO Base Operations, $3.70 million, $2.04 million below the FY 2017 Actual: NSO Base Operations includes the offices at NSO's Boulder, Colorado headquarters and the world-wide NSO Integrated Synoptic Program consisting of the GONG array and the SOLIS telescope. At the end of FY 2017, NSO ceased operating the Sacramento Peak Observatory in Sunspot, New Mexico and the McMath-Pierce Solar Telescope on Kitt Peak, Arizona as national user facilities. The funding profile for NSO Base Operations has been trending downward in anticipation of these divestments.

DKIST Operations, $16.50 million, $5.0 million above the FY 2017 Actual: Support for DKIST operations is through the R&RA account, while DKIST construction support is through the MREFC account. (See the MREFC chapter for more information on construction.) The FY 2019 Budget Request for DKIST Operations represents the final year of a five-year funding ramp that will bring the NSO budget to a level commensurate with requirements to operate DKIST. This profile is funding the development of the DKIST science operations and data center in preparation for full DKIST operations, which is expected to begin late 2019-early 2020.

Education and Public Outreach, $300,000, $40,000 above the FY 2017 Actual: 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 program. NSO has diverse education programs, including teacher training and curriculum development, visitor centers, and a web portal at www.nso.edu.

In preparation for the total solar eclipse in August 2017, and with the imminent arrival of DKIST, NSO significantly increased its education, public outreach, and broadening participation effort by establishing an Office of Education and Outreach. In FY 2016, NSO hired a new office head and recently filled a second EPO position, based in Maui, focused on DKIST.

Management and Oversight

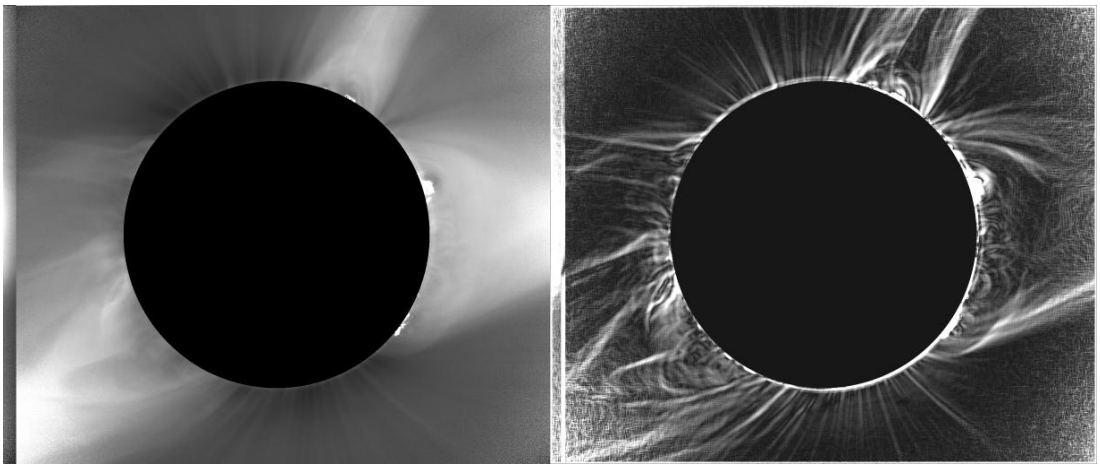
- NSF Structure: An NSF program officer in AST provides continuing oversight, including consultation with an annual NSF program review panel. The program officer makes use of detailed annual program plans, annual long-range plans, quarterly technical and financial reports, and annual reports submitted 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 Office of General Counsel, the Division of Acquisition and Cooperative Support, and the Large Facilities Office.

- 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 uses 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.
- Reviews: In addition to reviews held mid-way through all cooperative agreements, NSF conducts periodic and ad hoc reviews by external committees. In February 2017, NSF reviewed NSO's Annual Progress Report and Program Plan. From December 2015 through March 2016, NSF conducted a Business Systems Review covering AURA and NSO. Findings and recommendations from the final NSF report were conveyed to AURA in April 2016, and AURA continues to resolve issues and implement report recommendations. NSO also participated in reviews of the DKIST project in FY 2016 including: a contingency assessment (Feb. – July 2016) and an Earned Value Management System validation review (Sept. 2016), both of which are described in the DKIST narrative in the MREFC chapter.

Renewal/Recompetition/Termination

On August 14, 2014, the National Science Board (NSB) authorized a renewed cooperative agreement with AURA for management and operation of NSO. The renewed award was put into place in June 2015 and will run through September 2024.



Two snapshot images of the 2017 Great American Eclipse for the NSO-led Citizen CATE project. Left: Original image after processing with a mathematical transform that enhances faint structures in the outer solar corona. Right: Original image after processing with a mathematical transform that enhances the edges of faint structures in the outer solar corona. *Credit: M. Penn, NSO.*

OTHER ASTRONOMICAL FACILITIES **$11,850,000**
+$400,000 / 3.5%

Other Astronomical Facilities Funding
(Dollars in Millions)

FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual Amount	Percent
$11.45	-	$11.85	$0.40	3.5%

Other Astronomical Facilities consist of Green Bank Observatory (GBO) and Long Baseline Observatory (LBO). Prior to FY 2017, the National Radio Astronomy Observatory (NRAO) operated major radio telescopes at GBO in Green Bank, West Virginia, including the Robert C. Byrd Green Bank Telescope (GBT), and at 10 telescope array sites spanning the U.S. from the Virgin Islands to Hawai'i, together constituting the Very Long Baseline Array (VLBA). Beginning in FY 2017, GBO and VLBA were separated from NRAO. GBO now operates GBT, and the newly formed LBO operates VLBA. Associated Universities, Inc. (AUI) remains the managing organization for GBO and LBO through a cooperative agreement with NSF. This narrative presents the combined FY 2019 Budget Request for GBO and LBO.

GBO provides key ground-based radio-wavelength research facilities for the US national community, while carrying out a program in education for public visitors and students. The GBT is the world's largest fully steerable radio telescope and is GBO's flagship research instrument. From fundamental physics and astronomy to the discovery and characterization of interstellar organic molecules that provide insight to the organic chemistry of life on Earth, to the search for intelligent life beyond the Earth, the GBO contributes to a very broad area of scientific research. GBO is also the anchor and administrative site of the 13,000-square-mile National Radio Quiet Zone, where all radio transmissions are limited. Having telescopes within this quiet zone allows for detection of faint scientific signals that would otherwise be drowned-out by human-made signals.

LBO operates the Very Long Baseline Array (VLBA), the world's premier radio interferometer, using 10 identical 25-meter radio telescopes located across the U.S., from Hawaii to St. Croix Virgin Islands. The VLBA provides researchers with key insight into the structure and evolution of our galaxy, the Milky Way, and helps to determine the fundamental distance scale of the universe. In addition to basic astrophysical research, LBO contributes to the national infrastructure through the U.S. Naval Observatory's use of the VLBA for measuring daily Earth Orientation parameters, necessary to maintain the integrity of the GPS system. In September 2017, the VLBA antenna at St. Croix, Virgin Islands sustained a direct hit from Hurricane Maria. Although significant damage was sustained across the island of St. Croix, preliminary reports indicate that the VLBA antenna on St. Croix escaped serious damage. The power is now up and running. An expert team is expected to visit the site in February to assess when operations may resume. Funding for full repair of the St. Croix installation are provided in the Bipartisan Budget Act of 2018.

In 2010, the National Academies conducted their sixth decadal survey in astronomy and astrophysics. In their report, *New Worlds, New Horizons in Astronomy and Astrophysics*,[27] the 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

[27] www.nap.edu/catalog.php?record_id=12951

facilities." In response to this recommendation, the MPS Division of Astronomical Sciences (AST) conducted a community-based review of its portfolio. The resulting Portfolio Review Committee report, *Advancing Astronomy in the Coming Decade: Opportunities and Challenges*,[28] was released in August 2012 and included recommendations about all major AST telescope facilities.

In 2012, under constrained budgets, the Portfolio Review Committee recommended divestment of GBT and VLBA from AST funding because of a less compelling mapping to the science questions of the 2010 decadal survey compared to other facilities. As announced in a Dear Colleague Letter, NSF 13-074,[29] NSF partitioned GBT and VLBA from the competition for NRAO management and operations, which increased flexibility for exploring cost-efficient operational models and sustainable partnerships for GBO (comprising GBT and the Green Bank site and facilities) and VLBA. Existing partnerships are described below, and additional partner discussions with governmental and non-governmental entities are ongoing.

In FY 2016, AST received a proposal from AUI to continue management and operation of GBO and LBO in FY 2017 and FY 2018, separate from the management and operation of NRAO. Previously, the obligations for GBO and VLBA were heavily matrixed and not separable from the overall obligation for NRAO. Hence, GBO and VLBA, which were previously included in the NRAO narrative, were first presented as stand-alone entities in the FY 2017 Budget Request. The table below does not separate funding for GBO and LBO, as the detailed breakdown between the two depends on anticipated and achieved partnerships. Notional funding beyond FY 2020 is shown below, although it is expected that the outyear numbers will change significantly as partnerships evolve.

In FY 2017, pursuant to the National Environmental Policy Act, NSF began a formal environmental review of GBO to develop an Environmental Impact Statement (EIS), which will consider the environmental impact of various future alternatives for GBO. The process is expected to conclude in FY 2019 with publication of the final EIS, followed by a decision on the future path of the GBO, memorialized in a Record of Decision to be published by the NSF.

Total Obligations for Other Astronomical Facilities

(Dollars in Millions)

	FY 2017	FY 2018	FY 2019	ESTIMATES[1]				
	Actual	(TBD)	Request	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
Operations & Maintenance	$11.45	-	$11.85	$11.85	$11.85	$11.85	$11.85	$11.85

[1] Outyear funding estimates are for planning purposes only. The current cooperative agreement runs through September 2018 and is expected to be extended through September 2019.

GBO and LBO Operations and Maintenance, $11.85 million: This encompasses support for direct telescope operations at GBO and LBO, including maintenance, infrastructure upgrades, and telescope management as well as funds allocated for Education and Public Outreach.

Partnerships and Other Funding Sources: In FY 2017, GBO and LBO received approximately $8.80 million from other sources, roughly half from non-federal partners and half from other federal sources. External (non-NSF) contributions represented approximately 25 percent of the total operations budget of GBO and over 50 percent of the total operations budget of LBO. Many of the GBO and LBO partnerships involve guaranteed allocations of observing time on GBT or VLBA.

In FY 2016, GBO began a 10-year partnership with Breakthrough Listen and had funding partnerships with

[28] www.nsf.gov/mps/ast/ast_portfolio_review.jsp
[29] http://nsf.gov/pubs/2013/nsf13074/nsf13074.jsp

West Virginia University and the North American Nanohertz Observatory for Gravitational Waves (NANOGrav) consortium that are expected to continue through FY 2019. (The NANOGrav funding comes from the NSF award to the NANOGrav Physics Frontiers Center.) In addition, the GBO partnership with the RadioAstron space mission continues in FY 2018 and is anticipated to continue in FY 2019. Other partner discussions are ongoing.

In FY 2017, NSF and LBO established an agreement with the U.S. Naval Observatory to provide observing time and data in exchange for substantial support of LBO operations.

Management and Oversight

- NSF Structure: In consultation with community representatives, a dedicated AST program officer carries out continuing oversight and assessment for GBO and LBO by making use of detailed annual program plans, technical and financial reports, and annual reports submitted to NSF. The AST program officer attends AUI governance and advisory committee meetings. To address issues as they arise, AST works closely with other NSF offices, such as the Office of General Counsel, the Office of International Science and Engineering, 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 observatories through its own community-based oversight and users committees. The GBO and LBO directors report directly to the AUI Vice President for Radio Astronomy.
- Reviews: NSF conducts annual reviews of the Program Operating Plan and reports.

Renewal/Recompetition/Termination

GBO and LBO are currently supported through a cooperative agreement, which ends on September 30, 2018. NSF expects to extend the current agreement to continue support of GBO through September 30, 2019. Management of GBO after FY 2019 will be based on the further development of collaboration opportunities, the EIS process mentioned previously, and a potential solicitation. As for LBO, NSF expects to receive a proposal from AUI that will help to identify the future structure and operational support required for LBO and the VLBA beyond FY 2018.

OTHER FACILITIES FUNDING

Research and Related Activities Account Construction Projects
The R&RA account supports the acquisition, construction, and commissioning of the Antarctic Infrastructure Modernization for Science (AIMS) project. For information on AIMS funded through this account, refer to the Office of Polar Programs Chapter

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 (R&RA) 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 major 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 2019 Investments:

STEM Education and Workforce:

Other NSF-wide Activities:

INNOVATIONS AT THE NEXUS OF FOOD, ENERGY, AND WATER (INFEWS) **$16,400,000**
-$39,390,000 / -70.6%

Overview

Humanity is reliant upon the natural and physical systems of the Earth for provision of food, energy, and water (FEW) resources. With world population projected to increase to nine billion (U.S. population reaching 400 million) by 2050 and urban populations expected to double, there are expected to be major increases in demand for these resources. The INFEWS investment area enables interagency cooperation on one of the most pressing problems of the millennium—understanding interactions across the FEW nexus, how it is likely to affect our world, and how we can proactively plan for its consequences.

Food, energy, and water systems interconnect and are interdependent in many ways. Water is required for the production of energy—hydropower, cooling of electric power plants, energy production, etc. Energy is needed for wastewater treatment, desalination, pumping groundwater, and for transport of water. Water and energy are critical for agriculture and food production. Biofuels consume water and, in some instances, result in reductions in the production of food. In addition, different land use practices, increased urbanization, and climate variability have major impacts on all three. 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 the social, behavioral, and economic decisions made by individuals, organizations, and governments. Given the increased demand on these resources, societies can no longer sustain optimal operation for one system (i.e., food, energy, or water system)—we must plan our interaction within the FEW system of systems so that no single one fails even if it means that all operate sub-optimally.

The food, energy, and water nexus creates a grand research challenge: to understand how these complex, coupled processes and systems function now and in the future. There is also a critical need for research to enable new technologies that will enhance the productivity of the system and subsystems, maximize efficient overall usage of FEW resources, and define new means for socially and technologically adapting to future variability and demands. Investigations of this complex system will produce discoveries that cannot emerge from research on food or energy or water systems alone; the interactions among these components and the context(s) of the problem(s) they pose at the FEW nexus will produce new knowledge and technologies. NSF support of basic research in the science and engineering disciplines is needed to understand the interdependent and interconnected FEW systems and could lead to an integrated model useful not only for scientific understanding, but also informed decision-making.

INFEWS investments began in FY 2016 and are planned to continue through FY 2020. The overarching desired outcome of INFEWS is to improve understanding of the interdependencies of the FEW systems, within a disciplinary and interdisciplinary context. Supporting examples include:

- Improve understanding of FEW systems embedded in differing social contexts and the societal vulnerabilities of these systems with respect to short and long timescale events (e.g., weather, power outages, resource distribution, population pressures, and land-use changes).
- Advance scientific and engineering understanding to:
  - Improve systems models covering a range of environments, technologies, policies, individual and organizational behaviors, and relative weighting of FEW stresses/needs across the scope of the human, built, and natural environments;
  - Enable discoveries that lead to technological innovations incorporating sustainability, safety, security, efficiency, and affordability, while addressing relevant social, economic, and cultural factors; systems or models that promote efficient use of resources, as well as conversion and/or reuse of waste materials;
  - Inform technologies and policies that improve food security and agricultural practices that better

maintain ecosystem services;
- Strengthen partnerships with projects at the state and local levels that will test research results in real-world systems; and
- Encourage the results of modelling as well as technological and social solutions to be widely available to agencies, industries, and the public through computing interfaces that encourage interaction, contribution of additional data, and local application.

Goals

- Goal 1: Significantly advance our understanding of the FEW systems through quantitative and computational modeling, including support for advanced cyberinfrastructure;
- Goal 2: Develop real-time, cyber-enabled interfaces that improve understanding of the behavior of FEW systems and increase decision support capability;
- Goal 3: Enable research that will lead to innovative solutions to critical FEW system problems; and
- Goal 4: Grow the scientific workforce capable of studying and managing the FEW system, through education and other professional development opportunities.

Innovations at the Nexus of Food, Energy, and Water Systems
Funding by Directorate
(Dollars in Millions)

Dir/Office	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request
BIO	$7.50	-	-
CISE	5.83	-	-
EHR	6.00	-	-
ENG	9.70	-	5.00
GEO	7.70	-	8.00
MPS	8.78	-	-
SBE	4.50	-	2.50
OISE	1.28	-	0.90
IA	4.50	-	-
Total	**$55.79**	**-**	**$16.40**

NSF INNOVATION CORPS (I-CORPS™) **$30,000,000**
+$150,000 / 0.5%

Overview

NSF established the Innovation Corps (I-Corps™) program to accelerate the translation of scientific and engineering discoveries into technologies, products, processes, and services that enhance the nation's competitiveness, benefit society, and promote economic growth. NSF's investments in I-Corps™ strategically address the challenges inherent in the early stages of the innovation process by providing education, training, and mentoring to scientists, engineers, and entrepreneurs to enable them to identify and explore the commercial potential of NSF-funded research. The I-Corps™ program fosters a national innovation ecosystem that stimulates the translation of federally-funded research to a commercial stage more quickly and efficiently.

The I-Corps™ program was initiated in Fiscal Year 2011 and provides immersive, experiential entrepreneurial education to scientists and engineers who form I-Corps™ Teams. The program is building a National Innovation Network (NIN) comprising I-Corps™ Nodes and I-Corps™ Sites that work cooperatively to build, utilize, and sustain the national innovation ecosystem. The American Innovation and Competitiveness Act (AICA) was signed into law January 2017 (P.L. 114-329), and Section 601 of AICA directs NSF to develop and expand the I-Corps™ Program.

Goals

The goals of the I-Corps™ program are to:

- Spur translation of fundamental research to the marketplace;
- Encourage collaboration between academia and industry;
- Train NSF-funded faculty, students, and other researchers in innovation and entrepreneurship; and
- Maximize the potential of NSF's investments in basic research through creation of a National Innovation Network.

I-Corps™ Funding Levels
(Dollars in Millions)

Dir/Office	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request
BIO	$1.00	-	$1.00
CISE	11.65	-	11.65
EHR	1.52	-	1.55
ENG	12.91	-	13.00
GEO	0.60	-	0.60
MPS	1.69	-	1.70
SBE	0.49	-	0.50
Total	**$29.85**	**-**	**$30.00**

SECURE AND TRUSTWORTHY CYBERSPACE (SATC) **$129,000,000**
-$7,530,000 / -5.5%

Overview

In today's increasingly networked, distributed, and asynchronous world, cybersecurity involves hardware, software, networks, data, people, and integration with the physical world. Seemingly overnight, society has become deeply reliant on the smooth functioning of its digital infrastructure. Unfortunately, attacks on corporations, agencies, national infrastructure, and individuals have exposed the fragility and vulnerability of this complex cyberspace. Achieving a truly secure cyberspace requires addressing not only challenging scientific and engineering problems involving many components of a system, but also vulnerabilities that arise from human behaviors and choices. Examining the fundamentals of security and privacy as a multidisciplinary subject is the most promising approach to develop better ways to design, build, and operate cyber systems; to protect existing and future infrastructure; and to motivate and educate individuals about cybersecurity. Achieving these goals not only requires application of expertise in computer science, engineering, statistics, mathematics, social and behavioral science, economics, and education, but also the translation of new concepts and technologies into practice.

SaTC is a multi-year investment area, spanning FY 2014 - FY 2020. However, NSF's emphasis on cybersecurity research is expected to continue beyond FY 2020 because it constitutes an enduring challenge for science and engineering research and education that must evolve constantly to address new threats.

Outcomes from SaTC will include an organized scientific body of knowledge that informs the theory and practice of cybersecurity and privacy, and an improved understanding of the causes of and mitigations for current threats. SaTC will contribute to the development of foundational countermeasure techniques leveraging sound mathematical and scientific foundations, principled design methodologies, and socio-technical approaches that consider human, social, organizational, economic, and technical factors, as well as design metrics for evaluating success or failure of these approaches. In the space of training and education, SaTC will make recommendations for new instructional materials, degree programs, and educational pathways. Foundational research in SaTC will lead to a research community pursuing a broad and deep multidisciplinary research portfolio spanning cybersecurity and privacy, whose results underlie methods for securing critical infrastructure. Ultimately, through SaTC, NSF expects to produce an innovation ecosystem that ensures new and existing technologies are secure from attack and users' information is protected from violations of privacy despite the new attack surfaces these technologies present. Similarly, the creation of an American workforce and citizenry with an understanding of cybersecurity and privacy issues is an anticipated benefit of NSF's support of activities related to the education and training of cybersecurity researchers and professionals.

Goals

- Goal 1: Foundational Research: Develop the scientific theory, methodologies, and tools necessary to the development of trustworthy and usably secure systems and appropriate privacy safeguards.
- Goal 2: Accelerating Transition to Practice: 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.
- Goal 3: Education and Preparation of Cybersecurity Researchers and Professionals: Increase the number of qualified American students entering the fields of information assurance and cybersecurity, and enhance the capacity of higher education to produce professionals in these fields to meet the needs

of our increasingly technological society. This includes NSF's investment in the CyberCorps®: Scholarship for Service program, which supports cybersecurity education and workforce development.

Secure and Trustworthy Cyberspace
Funding Levels
(Dollars in Millions)

Dir/Office	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request
CISE	$73.00	-	$65.75
EHR	54.95	-	55.00
ENG	3.25	-	3.25
MPS	1.03	-	1.00
SBE	4.30	-	4.00
Total	**$136.53**	**-**	**$129.00**

UNDERSTANDING THE BRAIN (UTB) **$129,200,000**
-$30,660,000 / -19.2%

Overview

Understanding the Brain (UtB) is one of the grand scientific challenges at the intersection of the physical, life, behavioral, computing, and engineering sciences. In FY 2013, the multi-agency Brain Research through Advancing Innovative Neurotechnologies (BRAIN) Initiative was announced, with NSF as one of the lead participating agencies, and Congress reaffirmed its support for NSF's continued investments in the BRAIN Initiative as part of the 2017 American Innovation and Competitiveness Act (P.L. 114-329).[1] Through several new, cross-cutting programs and numerous existing core programs across the directorates, NSF will continue to support catalytic innovation in neuroscience as well as large-scale dissemination efforts to establish a national research infrastructure that will accelerate our understanding of brain function.

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 brain, behavior, and environment interact; 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 biophysical, molecular, physiological, and genetic to cognitive and behavioral, with the ultimate goals of establishing integrative, quantitative, computational, and predictive theories of brain structure, activity, and function.

NSF is uniquely positioned to address this challenge and continue advancing 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. Since FY 2014, the UtB activity has consolidated NSF's ongoing activities in cognitive science, neuroscience and the BRAIN Initiative. The UtB activity began in FY 2016 and will continue until FY 2020. NSF has been instrumental in supporting transformative breakthroughs in brain research and related technologies, such as optogenetics, the CLARITY brain preservation technique, and the first Food and Drug Administration (FDA) approved artificial retina, which all began with NSF support. The co-mingling of NSF's disciplinary and interdisciplinary fields is expected to foster new trans-disciplinary and convergent approaches to transform understanding of brain, cognition, behavior, and education, through the development of new technologies, theories, and fundamental research.

Goals

The overall goal of UtB is to enable scientific understanding of the full complexity and function of the brain in action and in context. This multi-year goal is being pursued across four ongoing priority areas:

1. Develop innovative neurotechnologies, new physical and conceptual tools, experimental approaches, theories, and models to monitor and analyze brain activity and integrate neuroscience information across scales and scientific disciplines;
2. Identify the fundamental relationships among neural architecture, activity, cognition, and behavior;
3. Transform our understanding of how the brain responds and adapts to changing environments; and
4. Train a new generation of scientists, engineers, and educators for a transdisciplinary, globally competitive workforce in neuroscience and neuroengineering.

[1] www.congress.gov/bill/114th-congress/senate-bill/3084/text

Understanding the Brain (UtB)
Funding Levels
(Dollars in Millions)

Dir/Office	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request
BIO	$46.39	-	$46.00
CISE	25.84	-	22.15
EHR	11.00	-	7.00
ENG	23.40	-	16.75
MPS	25.46	-	13.30
SBE	27.78	-	24.00
Total, UtB	**$159.86**	**-**	**$129.20**
BRAIN Initiative	*$89.73*	-	*$67.26*

IMPROVING UNDERGRADUATE STEM EDUCATION (IUSE) **$102,500,000**
+$400,000 / 0.4%

Overview

Improving Undergraduate STEM Education (IUSE) is an NSF-wide activity that supports both research about and implementation of high-quality undergraduate education in science, technology, engineering and mathematics (STEM), including computer science. High-quality undergraduate STEM education is vital to preparing a diverse professional STEM workforce that is equipped to sustain U.S. leadership in STEM innovation.[1,2] For example, STEM-related occupations represent about six percent of total U.S. employment[3] and the demand for workers in STEM-related occupations is expected to continue to grow at higher than average rates. Further, the average wage of STEM occupations is nearly double that of non-STEM occupations.[4] In addition to preparing the STEM workforce, high-quality undergraduate STEM education is also critical for producing STEM-knowledgeable workers who can use STEM skills in business and industry, and a STEM-literate public that supports and benefits from the progress of science.[5] By investing in improving the quality and effectiveness of undergraduate STEM education, IUSE directly contributes to national STEM needs and our scientific understanding of undergraduate STEM learning and learning environments.

IUSE can support projects in any NSF directorate, enabling IUSE to coordinate NSF investments in undergraduate STEM education across the Foundation. This coordination increases the potential impact of NSF investments in undergraduate education. IUSE supports investigators in a particular discipline to address discipline-specific issues, such as the need to recruit more women and minorities into computer science. IUSE investigators also contribute to issues that are relevant across all disciplines, such as incorporating active learning approaches.[6] The cross-directorate coordination provided by IUSE also supports science-driven innovations in undergraduate education, such as those needed to produce a STEM workforce that can use interdisciplinary approaches and/or massive data sets to identify and solve problems.

As part of its mission to advance STEM, NSF plans to invest $102.50 million in FY 2019. This funding represents investments within and across directorates, and is aligned with the IUSE funding strategies framework and the IUSE goals.

Goals

NSF undergraduate investments target one or more of the following three IUSE goals:

1. Improve STEM learning and learning environments at the undergraduate level. These investments improve the knowledge base for defining, identifying, and implementing innovative undergraduate STEM instruction that leads to improved student learning and fosters widespread use of evidence-based

[1] Hulten, C. (2017). The Importance of Education and Skill Development for Economic Growth in the Information Era. In Education, Skills, and Technical Change: Implications for Future US GDP Growth. University of Chicago Press. Retrieved from: www.nber.org/chapters/c13937.pdf

[2] Olson, S., & Riordan, D. G. (2012). Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics. Report to the President. Executive Office of the President. https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/pcast-engage-to-excel-final_2-25-12.pdf.

[3] www.bls.gov/opub/ted/2017/8-point-8-million-science-technology-engineering-and-mathematics-stem-jobs-in-may-2016.htm?view_full

[4] www.bls.gov/spotlight/2017/science-technology-engineering-and-mathematics-stem-occupations-past-present-and-future/pdf/science-technology-engineering-and-mathematics-stem-occupations-past-present-and-future.pdf

[5] National Academies of Sciences, Engineering, and Medicine. (2016). Science literacy: Concepts, contexts, and consequences. National Academies Press. Retrieved from: www.nap.edu/catalog/23595/science-literacy-concepts-contexts-and-consequences

[6] Freeman, S., et al. (2014). Active learning increases student performance in science. Proceedings of the National Academy of Sciences. 111: 8410-8415. Retrieved from: www.pnas.org/content/111/23/8410.abstract

resources and pedagogies in undergraduate STEM education.

2. Broaden participation and institutional capacity for STEM learning. These investments increase the number and diversity of undergraduate students recruited and retained in STEM fields and career pathways by implementing evidence-based, successful strategies to broaden participation and by growing that evidence base.
3. Build the STEM workforce for tomorrow. These investments improve the preparation of undergraduate students so that they can succeed as productive members of the future STEM and STEM-capable workforce, regardless of career path, and be engaged as members of a STEM-literate society.

The IUSE initiative's anchor investment is IUSE: Education and Human Resources (IUSE: EHR), a solicitation-based program in the EHR Division of Undergraduate Education (DUE). IUSE: EHR funds (1) innovative learning resources; (2) design of research questions to understand the impact of such resources; (3) strategies to implement effective instruction in a department or multiple departments, within or across institutions; (4) faculty development projects; (5) design and testing of instruments for measuring student outcomes; and (6) innovative activities that could have a high impact on learning and contribute to transforming undergraduate STEM education.

IUSE: EHR is complemented by five additional IUSE core programs:

- IUSE: Hispanic Serving Institutions (HSI Program);
- BIO: Research Coordination Networks: Undergraduate Biology Education (RCN: UBE);
- ENG: IUSE/Professional Formation of Engineers: REvolutionizing engineering Departments (IUSE/PFE: RED);
- CISE: innovation in undergraduate computer science education that enables, in part, the diffusion of computational thinking and computer science across a broad array of other fields (i.e. "CS+X").
- GEO/IUSE: Pathways into Geoscience (IUSE: GEOPATHS).

Together with IUSE: EHR, these six programs form the core of the IUSE framework of investments.

Improving Undergraduate STEM Education (IUSE)
Funding Levels
(Dollars in Millions)

Dir/Office	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request
BIO	$1.82	-	$2.00
CISE	1.99	-	2.00
EHR	87.01	-	87.00
ENG	4.97	-	5.00
GEO	6.31	-	6.50
Total	**$102.10**	**-**	**$102.50**

MAJOR INVESTMENTS IN SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS (STEM) GRADUATE STUDENTS AND GRADUATE EDUCATION

Overview

A U.S. science, technology, engineering, and mathematics (STEM) workforce with advanced preparation in research and innovation and in professional fields such as cybersecurity and STEM teaching, is essential for the progress of science and engineering (S&E). Today, emerging fields of S&E increasingly demand collaborations that span institutions, disciplines, and national boundaries, and require the use of sophisticated data infrastructure, instruments, and networks of researchers. Computationally intensive and data-enabled science is dramatically changing the knowledge and experience required of researchers and other STEM professionals across all fields. Thus, the preparation of graduate students in STEM must continue to evolve to provide a supply of scientists and engineers who not only meet the needs of the STEM enterprise, but who also have the knowledge, skills, and preparation to advance it and lead innovation in academia and the private and public sectors.

Investing in discoverers—that is, building a diverse and talented next-generation of STEM research leaders and professionals across sectors through inclusive processes—is an important NSF focus. A major portion of NSF's overall investment in graduate education and graduate students supports research assistants funded through research grants. NSF also supports graduate students through other mechanisms such as fellowships and traineeships.

Goals

The goal of NSF's 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 S&E, and to prepare professionals to participate and innovate in STEM intensive careers.

NSF's graduate STEM investments will do the following:

- Support training in areas of national S&E priority.
- 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.

FY 2019 Investments

NSF's two major agency-wide programs in graduate education are the Graduate Research Fellowship Program (GRFP) and the NSF Research Traineeship (NRT) program. EHR leads administration for both programs. NSF-wide working groups guide the management of these programs. Both programs contain design elements recommended in major national reports[1] as ways to better prepare graduates for a broad range of careers. GRFP has identified and supported outstanding, basic STEM researchers since 1952. The program also provides opportunities for graduate students to gain research experience internationally and in federal agencies. GRFP provides rich data that will be used for monitoring career outcomes longitudinally and will contribute to improving the understanding of STEM professional workforce development.

[1] American Chemical Society Presidential Commission (2012). Advancing graduate education in the chemical sciences. American Chemical Society, Washington, DC. Retrieved from www.acs.org/content/dam/acsorg/about/governance/acs-presidential-graduate-education-commission-full-report.pdf; Biomedical Research Workforce Working Group (2012). Biomedical Research Workforce Working Group Draft Report. National Institutes of Health, Bethesda. Retrieved from http://acd.od.nih.gov/bmw_report.pdf

There are several other programs at NSF that focus on developing sectors of the STEM workforce, and provide support to students in testing new models and approaches to graduate education. For example, the CyberCorps®: Scholarship for Service (SFS) program, led by EHR, addresses national need for a cybersecurity workforce as authorized by Public Law 113-274, Cybersecurity Enhancement Act of 2014. In addition to scholarships for undergraduate and graduate students, the program supports the expansion of existing educational opportunities and resources in cybersecurity through research on the teaching and learning of cybersecurity. Collaborators include CISE, the U.S. Department of Homeland Security, and the Office of Personnel Management. The Robert Noyce Teacher Scholarship program (Noyce) provides fellowship support to members of the master teacher cohort at the graduate level and funds innovation and development in STEM teacher education approaches. In addition to GRFP, NRT, SFS, and Noyce, the Louis Stokes Alliances for Minority Participation's Bridge to the Doctorate (LSAMP-BD) track, and NSF Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM) support the successful entry and transition of underrepresented and underserved populations into STEM graduate education and into the STEM workforce. This broad suite of programs contributes substantially to the NSF investment in graduate education of the STEM research and education workforce of the future.

In FY 2019, NSF directorates will be engaged in considering how to extend the range of professional development opportunities for graduate students across all NSF disciplines and will undertake several pilot activities. EHR is pursuing collaborations with other directorates to establish additional partnerships with industry for internship opportunities to give graduate students the professional development needed to pursue successful careers in STEM and STEM-related occupations. With OISE, EHR is seeking to expand graduate students' international research and professional development opportunities. The Dear Colleague Letter: Non-Academic Research Internships for Graduate Students (INTERN), NSF 17-091,[2] will provide supplemental funding in FY 2018 and FY 2019 for non-academic research internships for graduate students to support career opportunities. The Division of Graduate Education's (DGE) component of EHR's core research program will also emphasize research on the development of the STEM workforce.

[2] www.nsf.gov/funding/pgm_summ.jsp?pims_id=504991

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 2017[1]	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change Over FY 2017 Actual Amount	Change Over FY 2017 Actual Percent
Centers for Analysis & Synthesis	1995	3	$16.00	-	$4.40	-$11.60	-72.5%
Centers for Chemical Innovation[2]	1998	9	20.87	-	20.00	-0.87	-4.2%
Engineering Research Centers	1985	21	57.49	-	56.00	-1.49	-2.6%
Materials Centers[3]	1974	24	62.13	-	56.00	-6.13	-9.9%
Nanoscale Science & Engineering Centers[4]	2001	2	5.83	-	-	-5.83	-100.0%
Science & Technology Centers	1987	12	58.83	-	53.65	-5.18	-8.8%
Totals		**71**	**$221.14**	**-**	**$190.05**	**-$31.09**	**-14.1%**

[1] Counts include centers that received no-cost award extensions in FY 2017 but no additional funding.

[2] This presents Phase II CCI awards only. The smaller, developmental Phase I awards do not meet the criteria as formal NSF Centers and so are not captured here.

[3] Includes forward funding of $6.13 million in FY 2017. Without this action, FY 2019 Request would be level with FY 2017 Actual.

[4] The NSEC program sunset as planned in FY 2017.

Description of Major Changes

Centers for Analysis and Synthesis – BIO

The FY 2019 Request of $4.40 million funds one Center for Analysis and Synthesis—the National Social-Environmental Synthesis Center (SESYNC**)**. Both CyVERSE and the National Institute for Mathematical and Biological Synthesis received their final year of funding in FY 2017 and sunset as planned.

SESYNC, located at the University of Maryland, is dedicated to accelerating scientific discovery at the interface of human and ecological systems. This center allows scientists from diverse disciplines to transform approaches for identifying solutions to society's most challenging and complex environmental problems. Workshops sponsored by this Center engage philosophers, sociologists, political scientists, psychologists, anthropologists, and environmental biologists (together with policy makers) to integrate broad disciplines from the outset and to set precedence for all subsequent activities. This center underwent external review in FY 2016, and was granted a five-year renewal award that started in FY 2016 and will continue through FY 2020. FY 2019 funding will provide continued support for staff and core research activities.

Centers for Chemical Innovation (CCI) - MPS

The FY 2019 Request of $20.0 million funds five Phase II CCIs, four continuing, and one potential renewal. Funding for each of these CCIs will be $4.0 million per year.

The CCI program makes awards at two levels: smaller Phase I (three-year awards) for center development,

and larger Phase II for full centers (five-year awards with the potential for renewal for up to a total of ten years). Phase I awards are considered part of the NSF Division of Chemistry's core research program investments as they fall under the threshold for formal NSF center awards; thus, their funding is not captured here. In FY 2019, a Phase I CCI competition will be held, supporting up to three new developmental awards. No Phase I CCIs are eligible to compete for Phase II in FY 2019. An independent CCI evaluation was funded in FY 2017 and is expected to be completed in FY 2019.

Engineering Research Centers (ERC) - ENG

The FY 2019 Request of $56.0 million funds 14 ERCs. The total includes four Nanosystems Engineering Research Centers, three first funded in FY 2012 and one in FY 2017. 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.

The ERC program periodically commissions program-level evaluations by external evaluators to determine the effectiveness of ERC graduates in industry, the benefits of ERC membership to industry and others. In FY 2015, NSF funded the National Academies of Sciences, Engineering, and Medicine to study The Future of Center-Based, Multidisciplinary Engineering Research. To help inform the study, the National Academies held a public symposium on April 6, 2016, and published a proceedings.[1] The study report,[2] delivered May 2, 2017, articulates a vision for the future of NSF-supported center-scale, multidisciplinary engineering research, which ENG will carefully consider for the path ahead. A new solicitation for the next generation of ERCs is expected in FY 2018.

Reports include *Post-Graduation Status of Engineering Research Centers—2010* (SciTech Communications). This study, augmented by a recent update, found that of the 35 ERCs that have graduated from NSF support after 10 years, 29 (83 percent) are self-sustaining with strong financial support and most ERC features in place. The ERCs are successful at engaging a broader participation from underrepresented groups. For example, across an average of the currently active ERCs, approximately 32 percent of all those involved in the activities are women—in comparison to the national average of 16 percent across all engineering. In addition, the percentage of underrepresented minorities is more than three times that of engineering's national average. ERC products of innovation include 2,305 inventions disclosures, 1,909 patent applications filed, 790 patents awarded, and 1,345 licenses issued since the inception of the program. As for workforce development, ERCs have graduated 4,171 Bachelor's, 4,064 Master's, and 4,644 Doctoral degrees and impacted a total of 63,317 Pre-college K-12 Teachers and K-12 Students.

Materials Centers - MPS

The FY 2019 Request of $56.0 million is expected to fund 20 Materials Research Science and Engineering Centers (MRSECs). FY 2019 will be spent preparing for the next MRSEC competition in FY 2020. This includes stimulating the seeding efforts built within each MRSEC to start addressing DMR emerging research areas. These include the Quantum Leap, the Future of Work at the Human Technology Frontier, and Harnessing the Data Revolution for 21st-Century Science and Engineering Big Ideas, as well as Materials Sustainable Development research.

MRSECs exists to solve complex grand challenge materials problems requiring broad complementary multidisciplinary expertise within the physical sciences and engineering to understand materials phenomena, exploit materials behavior, and to create and discover new materials. Through the collaborative efforts involving academics, industrial, international and educational partners, MRSECs are a primary example of what is known as transdisciplinary convergent research.

[1] www.nap.edu/catalog/23645/a-vision-for-the-future-of-center-based-multidisciplinary-engineering-research
[2] www.nap.edu/catalog/24767/a-new-vision-for-center-based-engineering-research

MRSECs have five major components: interdisciplinary research thrusts, education and outreach, industrial outreach/partnerships, the materials research facilities network, which provides access to nearly 1,200 state-of-the art equipment instrumentation to materials researchers across the Nation, and the SEED program which enable MRSECs to rapidly react/move into new high risk and potentially transformative areas not yet fully explored. Each year, MRSECs produce about 210 PhDs in STEM fields, mentor over 450 research experience for undergraduate students and 60 research experience for teachers, and impact nearly 1 million students and parents through outreach activities such as summer camps, K-12 science curriculum development, K-12 in-school science demos, development and deployment of science kits, and partnering with the Nation's top museums to create STEM-related exhibits that impact the public. Since 1994, the program has created over 150 startups and produces yearly about 50 awarded patents and 30 patent licensures. MRSECs engage and assist about 220 industrial partners per year in advancing fundamental materials research that can be translated into the market place.

Science and Technology Centers: Integrative Partnerships (STC) - multi-directorate

The FY 2019 Request of $53.65 million will support twelve STCs and the administrative costs ($150,000) associated with management and oversight of the program. All are continuing awards from the FY 2010, FY 2013, and FY 2016 cohorts. Awards are for five years, with possible renewal for an additional five years, or 10 years total. Award sizes are typically $4.0 million to $5.0 million per year. Funding for the five centers in the 2010 cohort will sunset in FY 2020, with support beginning to ramp down in FY 2019. The STC program has developed a network of evaluators working with the centers to share information and lessons learned about the most effective way to measure progress at the centers.

The STC 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: engineering biological systems; energy-efficient electronics; new ways of handling the extraction, manipulation, and exchange of information; and new nano-atomic scale imaging modalities. 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 intellectually challenging research experiences for students, postdoctoral fellows, researchers, and educators; they advance public scientific understanding through partnerships with K-12 and informal education communities.

Estimates for Centers Participation in 2017

	Number of Participating Institutions	Number of Partners	Total FY 2017 NSF Support ($ in millions)	Total Leveraged Support ($ in millions)	Number of Participants
Centers for Analysis & Synthesis	2,163	954	$16	$0	12,666
Centers for Chemical Innovation	74	63	21	4	788
Engineering Research Centers	550	204	57	86	3,177
Materials Centers	516	372	62	47	5,070
Nanoscale Science & Engineering Centers	42	20	6	6	523
Science & Technology Centers	14	170	59	33	1,913

Number of Participating Institutions: All academic institutions participating in activities at the centers.

Number 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 2017

Center	Institution	State
Centers for Analysis and Synthesis		
National Institute for Mathematical & Biological Synthesis	U of Tennessee	TN
CyVERSE	U of Arizona	AZ
Socio-Environmental Synthesis Center	U of Maryland	MD
Centers for Chemical Innovation (Phase II awards only)[3]		
Center for Aerosol Impacts on Climate and the Environment	U of California-San Diego	CA
Center for Chemical Evolution	Georgia Institute of Tech	GA
Center for Chemical Innovation in Solar Fuels	California Institute of Tech	CA
Center for Enabling New Technologies through Catalysis	U of Washington	WA
Center for Selective C-H Functionalization	Emory	GA
Center for Sustainable Materials Chemistry	Oregon State	OR
Center for Sustainable Nanotechnology	U of Wisconsin	WI
Center for Sustainable Polymers	U of Minnesota	MN
Chemistry at the Space-Time Limit	U of California-Irvine	CA
Engineering Research Centers		
Advanced Self-Powered Systems of Integrated Sensors and Technologies (ASSIST)	North Carolina State	NC
Bio-mediated and Bio-inspired Geotechnics (CBBG)	Arizona State	AZ
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 (CCEFP)[1]	U of Minnesota	MN
Engineering Research Center for Innovative and Strategic Transformation of Alkane Resources (CISTAR)	Purdue	IN
Engineering Research Center for Precise Advanced Technologies and Health Systems for Underserved Populations (PATHS-UP)	Texas A&M	TX
Future Renewable Electric Energy Delivery and Management Systems (FREEDM)	North Carolina State	NC
Integrated Access Networks (CIAN)	U of Arizona	AZ
Nanomanufacturing Systems for Mobile Computing and Mobile Energy Technologies (NASCENT)	U of Texas	TX
Nanosystems Engineering Research Center for Directed Multiscale Assembly of Cellular Metamaterials with Nanoscale Precision (CELL-MET)	Boston College	MA
Nanotechnology Enabled-Water Treatment Systems (NEWT)	Rice University	TX
NSF Engineering Research Center for Cell Manufacturing Technologies (CMaT)	Georgia Tech	GA
Optimization for Electro-thermal Systems (POETS)	U of Illinois	IL
Quantum Energy and Sustainable Solar Technologies (QESST)	Arizona State	AZ
Re-inventing the Nation's Urban Water Infrastructure (ReNuWit)	Stanford	CA
Revolutionizing Metallic Biomaterials (RMB)	North Carolina A&T U	NC
Sensorimotor Neural Engineering (CSNE)	U of Washington	WA
Smart Lighting	Rensselaer Polytechnic Institute	NY
Structured Organic Particulate Systems[1]	Rutgers	NJ
Translational Applications of Nanoscale Multiferroic Systems (TANMS)	U of California-Los Angeles	CA
Materials Centers		
Brandeis Bioinspired Soft Materials Center	Brandeis	MA
Center for Dynamics and Control of Materials	U of Texas at Austin	TX
Center for Emergent Materials	Ohio State	OH
Center for Multifunctional Materials	Northwestern	IL
Center for Nanoscale Science	Pennsylvania State	PA

[3] Smaller, developmental Phase I awards do not meet the criteria as formal NSF Centers and so are not captured here.

Center for Photonic and Multiscale Nanomaterials	U of Michigan	MI
Center for Plasmonics and Organic Spintronics	U of Utah	UT
Center for Polarization and Spin Phenomena in Nanoferroic Structures	U of Nebraska	NE
Center for Research on Interface Structures and Phenomena	Yale	CT
Chicago Materials Research Centers	U of Chicago	IL
Columbia Center for Precision Assembly of Superstratic and Superatomic Solids	Columbia	NY
Cornell Center for Materials Research	Cornell	NY
Harvard Materials Research Center	Harvard	MA
Illinois Materials Research Center	U of Illinois at Urbana-Champaign	IL
Laboratory for Research on the Structure of Matter	U of Pennsylvania	PA
Materials Research Science and Engineering Center at UCSB	U of California-Santa Barbara	CA
Materials Research Science and Engineering Center	U of Minnesota	MN
MIT Center for Materials Science and Engineering	Massachusetts Institute of Tech	MA
NYU Materials Research Science and Engineering Center	New York U	NY
Princeton Center for Complex Materials	Princeton	NJ
Research Triangle Materials Research Science and Engineering Center	Duke, North Carolina State, NC Central U, U of North Carolina	NC
Soft Materials Research Center	U of Colorado	CO
UW Molecular Engineering Materials Center	U of Washington	WA
Wisconsin Materials Research Center	U of Wisconsin	WI
Nanoscale Science and Engineering Centers		
Center for the Environmental Implications of Nanotechnology (CEINT)	Duke	NC
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	MI
Biology with X-Ray Free Electron Lasers	SUNY Buffalo	NY
Center for Brains, Minds, and Machines: The Science and the Technology of Intelligence	Massachusetts Institute of Tech	MA
Center for Bright Beams	Cornell	NY
Center for Cellular Construction	U of California-San Francisco	CA
Center for Dark Energy Biosphere Investigations	U of Southern California	CA
Center for Emergent Behaviors of Integrated Cellular Systems	Massachusetts Institute of Tech	MA
Center for Energy Efficient Electronics Science	U of California-Berkeley	CA
Center for Engineering MechanoBiology	U of Pennsylvania	PA
Center for Integrated Quantum Materials	Harvard	MA
Science and Technology Center on Real-Time Functional Imaging	University of Colorado	CO
Center for Science of Information	Purdue	IN

PERFORMANCE

NSF PERFORMANCE FRAMEWORK

Per the GPRA Modernization Act of 2010, this chapter, together with the Overview, contains basic information about NSF's mission and Strategic Plan, as well as NSF's FY 2019 Annual Performance Plan (APP), Major Management Challenges, FY 2017 Annual Performance Report (APR), and Strategic Objective Progress Update. Information about NSF's performance can also be found on the NSF website in the FY 2017 Performance and Financial Highlights Report.[1]

Strategic Plan and Strategic Objectives

Alongside this Request, NSF releases its new Strategic Plan for FYs 2018-2022: *Building the Future: Investing in Discovery and Innovation.*[1] This Plan lays out two strategic goals that embody the dual nature of NSF's mission to advance the progress of science while benefitting the Nation: *Expand knowledge in science, engineering, and learning* and *Advance the capability of the Nation to meet current and future challenges*. A third goal, *Enhance NSF's performance of its mission*, directs NSF to hold itself accountable for achieving excellence in carrying out its mission. Each goal has two Strategic Objectives which together encompass all areas of agency activity. This goal structure enables NSF to link its investments to longer-term outcomes.

Strategic Goal	Strategic Objective
1 Expand knowledge in science, engineering, and learning.	**1.1 Knowledge** Advance knowledge through investments in ideas, people, and infrastructure.
	1.2 Practice Advance the practice of research.
2 Advance the capability of the Nation to meet current and future challenges.	**2.1 Societal Impacts** Support research and promote partnerships to accelerate innovation and to provide new capabilities to meet pressing societal needs.
	2.2 STEM Workforce Foster the growth of a more capable and diverse research workforce and advance the scientific and innovation skills of the Nation.
3 Enhance NSF's performance of its mission.	**3.1 Human Capital** Attract, retain, and empower a talented and diverse workforce.
	3.2 Processes and Operations Continually improve agency operations.

FY 2018-2019 Agency Priority Goal

In this Request, NSF is establishing an Agency Priority Goal (APG) to *Expand public and private partnerships to enhance the impact of NSF's investments and contribute to American economic competitiveness and security*. By September 30, 2019, NSF's number of partnerships and/or award actions with other federal agencies, private industry, and foundations/philanthropies will grow by five percent, relative to the FY 2017 baseline, to make available infrastructure, expertise, and financial resources to the U.S. scientific and engineering research and education enterprise.

FY 2019 Performance Plan

NSF's FY 2019 APP continues two goals aimed at monitoring of key program and infrastructure investments. The FY 2019 APP also includes two goals aimed at maintaining and improving customer service: NSF's longstanding performance goal to make timely award decisions and a goal new in FY 2018

[1] www.nsf.gov/about/performance

that focuses on improving the quality of the reviews written by outside reviewers. This goal includes new targets for FY 2019 associated with the agency's reform plan. NSF's long-standing diversity and inclusion goal has been updated to focus on leadership engagement. In addition to the APG on partnerships, which supports agency reform efforts, NSF has also added new performance goals tied to the agency reform plans to ensure alignment of job requirements with competencies and improve user interactions with IT systems.

FY 2017 STRATEGIC OBJECTIVE PROGRESS UPDATES

In FY 2017, the National Science Foundation conducted Strategic Reviews of the seven Strategic Objectives in its 2014-2018 Strategic Plan, in response to the requirement of the GPRA Modernization Act 2010 Section 1116(f).

The FY 2017 strategic review was a high-level assessment of the NSF strategic review process. The strategic review team assessed both the aggregate outcomes of the recommendations from all the earlier reviews as well as the effectiveness of the strategic review process itself. The strategic review required substantial data collection and analysis to provide the evidence to objectively assess the process and support recommendations to improve the process. The strategic review team included members from the National Center for Science and Engineering Statistics, NSF's Evaluation and Assessment Capability, and program staff. The team conducted a survey of past participants to obtain views on the strategic review process, interviewed past participants to obtain more contextual information, and reviewed the actions and progress of prior year's recommendations.

Several key findings were emphasized in the strategic review report:

- The process was effective and could be useful as a model for other evidence-based decision-making efforts at NSF. Aspects of the process that were considered to be particularly strong included composition of the teams with specific subject matter expertise, team leadership, well-defined timeline and specific deliverables, and the data and analytic support provided to the strategic review teams.
- The assessment found that action has been taken on 75 percent of Strategic Review recommendations. 47 percent of actions recommended were fully completed.

Key recommendations made by the report included:

- The strategic review process should be considered as a framework for data-driven decision-making throughout the National Science Foundation.
- The strategic review process should be used as a model for leadership and staff engagement for agency-wide planning and priority setting.
- The efficiency and effectiveness of other NSF decision-making groups could be improved by incorporating these aspects of the strategic review process: a defined timeline, specific deliverables, and data and analytic support.
- Participants should continue to be selected based on their subject matter expertise and their leadership and teamwork skills.
- Communications with NSF staff should be improved, particularly at the beginning and end of the process.

All recommendations were accepted by senior management, and many of these actions are already underway including the final recommendation to consider the strategic review framework for broad based decision-making throughout NSF.

FY 2019 ANNUAL PERFORMANCE PLAN

NSF's FY 2019 Annual 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 2019. The remaining pages of this section provide a detailed description of each goal along with the proposed target measures, milestones, or deliverables.

	Performance Goal	**Lead Organization**	**Goal Statement**
1	APG: Expand Public and Private Partnerships	CISE	Expand public and private partnerships to enhance the impact of NSF's investments and contribute to American economic competitiveness and security.
2	Ensure that Key Program Investments are on Track	BFA	Ensure that key FY 2019 NSF-wide program investments are implemented and on track.
3	Ensure that Infrastructure Investments are on Track	BFA/LFO	Ensure program integrity and responsible stewardship of major research facilities and infrastructure.
4	Make Timely Award Decisions	OIA/OD and BFA	Inform applicants whether their proposals have been declined or recommended for funding in a timely manner.
5	Improve Review Quality	OIA/OD	Improve the quality of written reviews of NSF proposals.
6	Foster a Culture of Inclusion	ODI/OD	Foster a culture of inclusion through active engagement of leadership.
7	Align job requirements with competencies.	OIRM/HRM	By the end of FY 2019, the Division of Human Resource Management will review, modernize, or eliminate 10 percent of the existing position descriptions requiring review.
8	Improve user interactions with IT systems	CIO and OIRM/DIS	Streamline and simplify user interactions with IT systems and functions that support the merit review process, reducing non-value-added steps and reducing the time spent managing the proposal and award lifecycle.

Goal 1: Agency Priority Goal: Expand Public and Private Partnerships

Goal Statement	Expand public and private partnerships to enhance the impact of NSF's investments and contribute to American economic competitiveness and security.
Indicator and Target Measure, Milestone, or Deliverable	By September 30, 2019, NSF's number of partnerships and/or award actions with other federal agencies, private industry, and foundations/philanthropies will grow by five percent, relative to the FY 2017 baseline, to make available infrastructure, expertise, and financial resources to the U.S. scientific and engineering research and education enterprise.
Description	This goal aligns with one of the four agency operational reform areas described in this Request's Overview. Private industry, foundations, and non-profits, together with other federal agencies and international funding organizations, bring additional expertise, resources, and capacity to NSF-funded research. This, in turn, accelerates discovery and translation of research to products and services, and enhances preparation of the future workforce to benefit society and grow the American economy. Partnerships require significant time and intellectual capital, as well as strategic foresight, in their development. NSF will improve efficiencies in developing, implementing, and managing partnerships to ultimately grow the number and scope of partnerships and maximize the scientific, economic, and societal impacts of its investments. An implementation plan for this APG will be posted on performance.gov.
Trend Information	This is a new activity in FY 2018.
Lead Organization/s	Computer and Information Science and Engineering,

Goal 2. Ensure that Key Program Investments are on Track

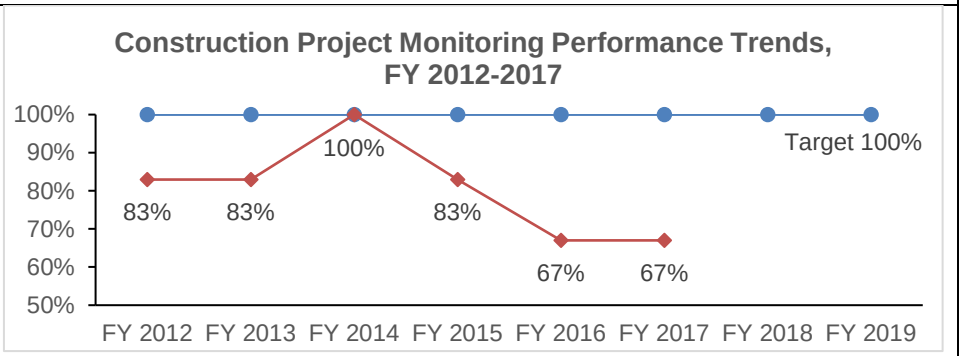
<table>
<tr><td>Goal Statement</td><td>Ensure that key FY 2019 NSF-wide program investments are implemented and on track.</td></tr>
<tr><td>Indicator and Target Measure, Milestone, or Deliverable</td><td>1. Monitor the progress of selected NSF-wide investments using a common set of milestones and indicators: Understanding the Brain (UtB) and Secure and Trustworthy Cyberspace (SaTC).
2. Review the results with senior leaders quarterly in data-driven performance reviews.</td></tr>
<tr><td>Description</td><td>Each year, NSF highlights a number of cross-agency investments in the NSF-Wide Investments chapter of its Budget Request to Congress. Although the overall impact of these investments will not be realized for many years, tracking near-term indicators of implementation and progress can help the agency make formative changes or course corrections.

Key investments will be selected at the beginning of FY 2019 for strategic monitoring with 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.

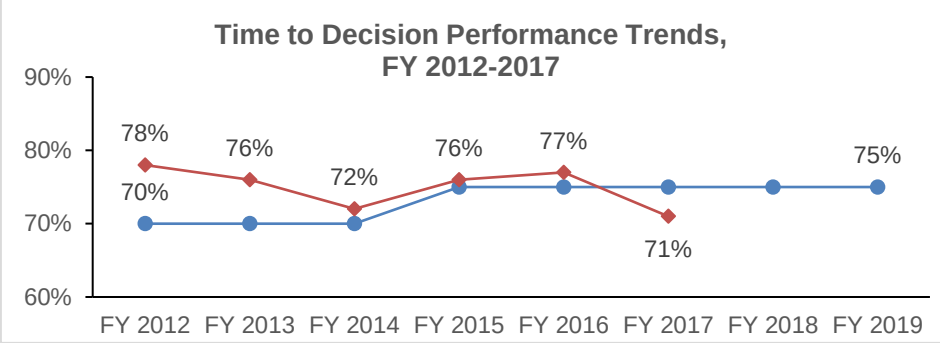
Progress will be assessed quarterly and discussed at quarterly review meetings with leadership.</td></tr>
<tr><td>Trend Information</td><td>This has been a goal since FY 2014.

<table><tr><th>FY</th><th>Target</th><th>Result</th></tr><tr><td>2017</td><td>Monitor 4 programs (NSF INCLUDES, INFEWS, Risk and Resilience, and UtB); review results with leadership.</td><td>Achieved.</td></tr><tr><td>2016</td><td>Monitor 3 programs (NSF INCLUDES, INFEWS, and UtB).</td><td>Achieved.</td></tr><tr><td>2015</td><td>Monitor 4 programs (CEMMSS, CIF21, SaTC, and SEES).</td><td>Achieved.</td></tr><tr><td>2014</td><td>Monitor 6 programs (CEMMSS, CIF21, I-Corps™, INSPIRE, SaTC, and SEES)</td><td>Not achieved (4 of 6 monitored).</td></tr></table>
The list of monitored programs is subject to change each year based on investment priorities for a particular year.</td></tr>
<tr><td>Lead Organization/s</td><td>Office of Budget, Finance, and Award Management</td></tr>
</table>

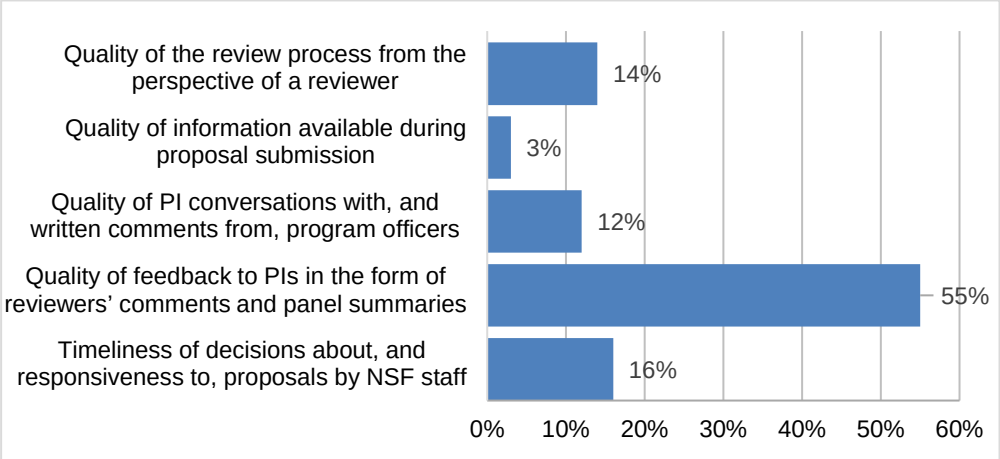
Goal 3: Ensure that Infrastructure Investments are on Track

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 (100 percent) 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 major facility projects by monitoring cost and schedule variances using Earned Value Management (EVM), a standard measure of performance for construction projects. Projects that are under 10 percent complete are not reported against this goal because EVM data are statistically less meaningful in early stages. The final Q4 EVM results for the reportable projects in the construction stage are used to determine whether NSF has met this goal.
Trend Information	 Note: NSF currently has only three projects in the construction stage that are greater than 10 percent complete due to project completions since FY 2015. For more details on these projects, see the MREFC chapter of this Request.
Lead Organization/s	Large Facilities Office, Office of Budget, Finance, and Award Management

Goal 4: Make Timely Award Decisions

Goal Statement	Inform applicants whether their proposals have been declined or recommended for funding in a timely manner.
Indicator and Target Measure, Milestone, or Deliverable	75 percent of proposal funding decisions are made within 182 days 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. An important issue 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 weaken the merit review process by forcing premature decisions. The optimal dwell time depends on a number of factors including the complexity of the proposed activity, the need for co-review by more than one panel, the need for site review, infrastructure requirements of the proposed activity, and the potential size of the award. Large, complex proposals require more time under review to ensure that taxpayer dollars are invested wisely.
Trend Information	 NSF has tracked six month dwell time as a performance goal for over a decade and has consistently met a target of 70 percent. In FY 2015, the six month target was increased to 75 percent. NSF did not meet the 75 percent target in FY 2017 for reasons relating to its move to new headquarters at the end of the fiscal year. For more detail, see the FY 2017 Performance Report.
Lead Organization/s	Office of Integrative Activities, Office of the Director Office of Budget, Finance, and Award Management

Goal 5: Improve Review Quality

Goal Statement	Improve the quality of written reviews of NSF proposals.
Indicator and Target Measure, Milestone, or Deliverable	By September 30, 2019, 1. 60 NSF programs will have had reviewers view the presentation "Tips on how to write better reviews." 2. 8,000 reviewers of NSF proposals will have viewed "Tips on how to write better reviews" prior to preparing written reviews. 3. Improve the perceptions reported by survey respondents in a repeat survey of proposers and reviewers. • Increase the percentage of PI survey respondents who agree that written reviews are thorough from a baseline of 55 percent (2015) to 57 percent in FY 2019. • Increase the percentage of PI survey respondents who agree that written reviews are technically sound from a baseline of 63 percent (2015) to 65 percent in FY 2019.
Description	This goal aligns with one of the four agency operational reform areas described in this Request's Overview. This goal addresses and incorporates feedback NSF has received about its customer service. Committees of Visitors (COVs), program officers, and principal investigators frequently note that the quality of individual written reviews is variable. In 2015, NSF conducted a survey of researchers who were submitting and/or reviewing proposals. Survey respondents identified the quality of reviews as the factor that would have the most significant effect on improving their proposals and fostering science (see chart below, *n*=22,174 respondents).  This goal measures the implementation of a pilot program, initiated in December 2016, to improve the quality of written reviews of NSF proposals. The pilot encourages NSF programs to use the video presentation "Tips on how to write better reviews" early in the review process to orient reviewers and provide information on how to write more effective reviews. The assumption is that orienting reviewers before the reviews are written (as opposed to at the beginning of a review panel, at which time the reviews have been drafted but not finalized) helps reviewers better understand and apply the review criteria. The intention is to make written reviews more useful to both principal

	investigators and NSF program staff. NSF will conduct another survey in FY 2019 to learn whether the perceived quality of reviews has changed. The anticipated survey will take upwards of a year to field and analyze following the pilot program. For additional information about how this performance goal is aligned with reform efforts, costs and savings, and a multi-year roadmap of this activity, please see the Agency Reform Plan chapter.
Trend Information	A strategic review in the spring of 2015 recommended that NSF apply what was learned from the PI and reviewer survey to inform a new performance goal aimed at improving customer service. This goal was designed in response to that recommendation and was new in FY 2018.
Lead Organization/s	Office of Integrative Activities, Office of the Director

Goal 6: Foster a Culture of Inclusion

<table>
<tr><td>Goal Statement</td><td>Foster a culture of inclusion through active engagement of leadership.</td></tr>
<tr><td>Indicator</td><td>To be determined in spring 2018.</td></tr>
<tr><td>Description</td><td>NSF puts a high premium on diversity and inclusion: by engaging the talent of all our workforce, individuals are empowered to realize their full potential; by insuring that our workforce is diverse, our collective ability to deliver on our scientific mission is enhanced. NSF is always looking for ways to intensify and innovate diversity efforts through active leadership and include and engage everyone in the workplace.

In mid-FY 2018, NSF is establishing a new Diversity and Inclusion Leadership Group that will help NSF to continue its effort to attract, retain, and cultivate diverse leaders and staff. The group will have members representing a cross-section of NSF employees: leadership, the NSF Union, administrative staff, and programmatic staff. The Head of ODI, the Chief Human Capital Officer (CHCO), the Deputy CHCO, and the Labor Relations Officer will serve in an advisory capacity to the group as ex-officio (non-voting) members. The group will be action-oriented, proposing approaches to cultivate and model a workplace culture that supports inclusion, collaboration, employee engagement, transparency, and information sharing to enable the NSF to achieve the highest level of organizational performance.

Once the group is established, it will plan its first few years of activities. Targets for FY 2019 will be established in spring of 2018.</td></tr>
<tr><td>Trend Information</td><td>NSF has had a performance goal relating to diversity and inclusion since FY 2011. For five years, goals were largely focused on NSF's efforts to attain "Model EEO Agency" status. Inclusion represented a new direction for this goal since FY 2016. For more information, refer to the FY 2015 APR in the FY 2017 NSF Budget Request.[1]

<table>
<tr><th>FY</th><th>Target</th><th>Result</th></tr>
<tr><td>2017</td><td>Conduct the New IQ process with two NSF units, improve the units' New IQ Self-Survey Scores by five percent above established baseline.</td><td>Not achieved.</td></tr>
<tr><td>2016</td><td>Conduct the New IQ process with two NSF units, improve the units' New IQ Self-Survey Scores by five percent above established baseline.</td><td>Not achieved.</td></tr>
<tr><td>2015</td><td>Attain six of six essential elements of a model EEO agency, perform two compliance desk reviews under antidiscrimination laws.</td><td>1 of 2 targets achieved.</td></tr>
<tr><td>2014</td><td>Attain six of six essential elements of a model EEO agency, perform two compliance desk reviews under antidiscrimination laws.</td><td>Not achieved.</td></tr>
<tr><td>2013</td><td>Attain five of six essential elements of a model EEO agency.</td><td>Achieved.</td></tr>
</table>
</td></tr>
<tr><td>Lead Organization</td><td>Office of Diversity and Inclusion, Office of the Director</td></tr>
</table>

[1] nsf.gov/about/budget/fy2017/pdf/56_fy2017.pdf

Goal 7: Align job requirements with competencies.

Goal Statement	Ensure that employee job requirements are aligned with competencies and skills needed for the future.
Indicator and Target Measure, Milestone, or Deliverable	By the end of FY 2019, the Division of Human Resource Management will review, modernize, or eliminate 10 percent of the existing position descriptions requiring review.
Description	This goal aligns with one of the four agency operational reform areas described in this Request's Overview. Technological improvements have automated many tasks once performed by NSF staff. Requirements for NSF's administrative staff have evolved from the more traditional competencies related to general clerical and office tasks such as categorizing, processing and tracking paper forms to more advanced competencies related to the use of multiple automated data systems. Additionally, the increasing high number of proposals NSF receives, processed by the relatively stable number of program officers, means greater support is needed in data processing, data mining, analytics, and use of automated processes. NSF is also putting into place efforts to enable transdisciplinary, convergent research, and the agency needs to ensure its current and future workforce can adapt to this convergent approach. NSF will review and realign its workforce to ensure its greatest resource – its people – are equipped with the knowledge, skills, and abilities for success now and in the future. Ultimately, this will result in increased alignment between NSF's organizational structure, its core mission, and strategic plan. NSF will improve performance and increase accountability by systematically reviewing the NSF workforce from top to bottom. This review will allow NSF to revise position descriptions (PDs) that are outdated or do not reflect current and future work responsibilities. This PD modernization effort will enable NSF to identify the skills needed in today's work environment and will establish more relevant opportunities for training and developing NSF's existing workforce, while also enabling hiring managers to better target recruitment and outreach efforts to obtain the highest caliber of external candidates.
Trend Information	This will be a new activity in FY 2018 and FY 2019 relating to agency operational reform.
Lead Organization/s	Division of Human Resource Management, Office of Information and Resource Management

Goal 8. Improve user interactions with IT systems.

Goal Statement	Streamline and simplify user interactions with IT systems and functions that support the merit review process, reducing non-value-added steps and reducing the time spent managing the proposal and award lifecycle.
Indicator and Target Measure, Milestone, or Deliverable	1. By the end of FY 2019, NSF IT systems will have been available 99.5 percent of the time, excluding 469 hours of planned downtime. 2. By the end of FY 2019, 72 percent of internal merit review functions will be accessible through a single portal. 3. By the end of FY 2019, 32 percent of external merit review functions will be accessible through a single portal.
Description	This goal aligns with one of the four agency operational reform areas described in this Request's Overview. As NSF positions itself to operate as a more agile organization, information technology (IT) will play a major role in enabling NSF's mission and allowing NSF to remain flexible to adapt to reform areas. NSF will look to leverage state-of-the-art IT solutions from the private and public sectors to develop flexible tools that support the formation of agile work teams; to drive changes in the way research is solicited, identified, and funded; and to ensure user adoption is achieved to the maximum extent possible while also easing the use of IT systems. This emphasis on efficiency and improved service to end users will ensure that IT responds rapidly to changes in the way NSF is organized and carries out its mission, with the goal of ensuring that NSF IT tools minimize staff workload and simplify decision-making by providing accurate data, easy-to-use interfaces, and readily available and reliable access. Indicator 1, Percent of Systems Availability, measures the amount of time that the system is up and running, AND is available for access because connectivity is available (i.e. no network or internet outages impact accessibility). Indicator 2 is the percentage of internal merit review functions accessible through a single portal. Indicator 3 is the percentage of external merit review functions accessible through a single portal. For more information about implementation, costs and savings, and a multi-year roadmap of this activity, please see the Agency Reform Plan chapter.
Trend Information	As of June 30, 2017, the values for the three indicators were: 1. Systems Availability: 99.7 percent, excluding planned downtime. 2. Internal merit review functions available through a single portal: 59 percent. 3. External merit review functions available through a single portal: 14 percent.
Lead Organization/s	Office of the Chief Information Officer and the Division of Information Systems, Office of Information and Resource Management

FY 2017 ANNUAL PERFORMANCE REPORT

In FY 2017, NSF tracked progress toward its three strategic goals using nine performance goals, two of which were Agency Priority Goals (APGs). Four of the nine goals fully achieved their targets in FY 2017 and five did not achieve one or more targets. Below is a tabular summary.

Goal ID	Performance Goal	FY 2016 Result
1	APG: Improve Graduate Student Preparedness	Achieved
2	APG: Invest Strategically in Public Participation in STEM Research	Achieved
3	Ensure that Key Program Investments are on Track	Achieved
4	Ensure that Research Infrastructure Investments are on Track	Not Achieved
5	Use Evidence to Guide Management Decisions	Partially Achieved
6	Make Timely Award Decisions	Not Achieved
7	Foster a Culture of Inclusion	Not Achieved
8	Evaluate NSF Investments	Achieved
9	Increase the Percentage of Panelists Participating in Merit Review Virtually	Not Achieved

Multiple years of trend data are available for NSF's quantitative performance measures (Goals 4, 6, and 9). Other performance goals monitor progress towards multiyear goals, such as implementation of a new process (Goals 7 and 8) or monitoring of strategically important investments (Goals 1, 2, 3, and 5).

Goal 1: Improve Graduate Student Preparedness (Agency Priority Goal)

Lead Organizations: Directorate for Geosciences, Directorate for Engineering, Directorate for Social and Behavioral Sciences.

Goal Statement

Improve STEM graduate student preparedness for entering the workforce.

Measure, Milestone, or Deliverable

FY	*Target*	*Final 2-Year Result*
2016-2017	By September 30, 2017, NSF will fund at least three summer institutes and 75 supplements to existing awards to provide STEM doctoral students with opportunities to expand their knowledge and skills to prepare for a range of careers.	Summer Institutes = 5 Supplements = 163
Trend Information		
This was a new goal in FY 2016. The topic was identified through the 2015 Strategic Review process.		

Discussion

A strong global economy relies on the ability to capitalize on technical innovations that result from a skilled and agile STEM workforce. To achieve this, the Nation's scientific workforce must evolve and mature to include more doctoral level researchers in positions outside of academia. These positions require comprehensive preparation in science at the graduate level, as well as proficiency in other critical skills. However, Ph.D. training remains largely focused on preparation for the research component of academic careers with an emphasis on skills needed at research institutions.

The purpose of this APG was to provide opportunities for science and engineering doctoral students to acquire the knowledge, experience, and skills needed for highly productive careers, inside and outside of academe. To achieve this goal, NSF took two approaches: piloting support for summer institutes, to provide students with broad experiences in professional development areas, and supporting supplements to existing research awards, to enhance graduate education opportunities. Supplements were categorized as either enhancing the student's *experience* or *activities*. Enhanced experience awards were single or collaborative awards for graduate students to acquire professional development experience. Enhanced activity awards went to "center-like" activities that support cohorts of graduate students with the goal of developing new "best practice activities for enhancing graduate student preparedness."

Goal Category	**FY 2016**	**FY 2017**	**Total**
Summer Institutes	1	4	5
All supplements	80	83	163
Enhanced experience	*68*	*77*	*139*
Enhanced activity	*12*	*6*	*18*

A portfolio analysis of the awards made under this APG is underway to inform future decision-making in this area.

Goal 2: Invest Strategically in Public Participation in STEM Research (PPSR) (Agency Priority Goal)

Lead Organizations: Directorate for Computer and Information Sciences and Engineering, Directorate for Education and Human Resources.

Goal Statement

Build the capacity of the Nation to solve research challenges and improve learning by investing strategically in crowdsourcing and other forms of public participation in science, technology, engineering, and mathematics research (PPSR).

Measure, Milestone, or Deliverable

FY	*Target*	*Final 2-Year Result*
2016-2017	By September 30, 2017, NSF will implement mechanisms to expand and deepen the engagement of the public in research.	EAGERs = 34 projects Supplements = 18 Research Coordination Networks = 2
Trend Information		
This was a new goal in FY 2016. The topic was identified through the 2015 Strategic Review process.		

Discussion

Scientists, mathematicians, and engineers have involved the public in their research efforts to solve challenging problems for centuries. These types of activities have been referred to in a variety of ways. For this goal, PPSR is used as an overarching term that includes citizen science, crowdsourcing research, and similar activities. PPSR has grown significantly in the past decade, in part due to new technological tools that facilitate interactions between scientists and participants. PPSR approaches can address new research questions and contribute to ongoing STEM research.

To achieve this APG, NSF used three specific funding mechanisms to fund proposals that explicitly include PPSR approaches:

- Early-concept Grants for Exploratory Research (EAGERs) are designed as "high risk-high payoff" awards with the potential to explore new areas within PPSR and/or further our understanding of how PPSR is leveraged to support scientific discovery and the public's engagement with research. NSF aimed to fund five EAGERs a year that included PPSR. Across both years, 40 such EAGERs, funding 34 separate projects,[1] were funded by five different directorates.
- Supplements to existing awards provide opportunities to include PPSR approaches in projects that are appropriate for PPSR but hadn't already incorporated PPSR approaches. NSF aimed to fund five supplements a year that included a focus on PPSR. At least 18 supplements supporting PPSR were funded over the two-year period, across at least five directorates. More supplements that meet the criteria may be identified.
- Research Coordination Networks (RCNs) support communication and coordination across disciplinary, organizational, institutional, and geographic boundaries. Two RCNs that support PPSR were funded over the APG period.

Over the course of FY 2016 and FY 2017, six Dear Colleague Letters were issued that called for proposals that helped achieve this APG, including one that was specifically issued as a result of the Priority Goal (NSF 17-047, “Dear Colleague Letter (DCL): Public Participation in Science, Technology, Engineering,

[1] Some projects were submitted as collaborative proposals, resulting in multiple awards.

and Mathematics Research: Capacity-building, Community-building, and Direction-setting").

NSF also used mechanisms designed to receive input from stakeholder communities to ensure that its efforts to support PPSR were appropriately informed:

- Convened stakeholders external to the federal government to help NSF identify trends, opportunities, and gaps in PPSR, and inform how NSF targets funding opportunities towards scientific needs and public audiences. Over the two-year timeframe of this goal, NSF officials interacted with two NSF Advisory Committees and the national Citizen Science Association (CSA) steering committee, and conducted outreach at CSA's biennial meeting, among others. NSF also funded three PI-led conferences with significant PPSR components and called for conference proposals to support PPSR in NSF 17-047.
- Conferred with other federal agencies to inform and coordinate efforts related to PPSR. At least 17 such conferrals occurred in the timeframe of this goal, most often with the Office of Science and Technology Policy and the Federal Community of Practice for Crowdsourcing and Citizen Science, as well as with the Networking and Information Technology Research and Development Social Computing Interagency Working Group.
- Issued communications highlighting PPSR and related funding opportunities. A total of six funding opportunities were released, as well as a video, "Pick Your Passion with Citizen Science".[2]
  - NSF 16-031: DCL: Leveraging GLOBE to Increase Student Engagement and Diversity
  - NSF 16-059: DCL: Citizen Science and Crowdsourcing–Public Participation in Engineering Research
  - NSF 16-119 DCL: Support for Engaging Students and the Public in Polar Research
  - NSF 17-047: DCL: Public Participation in Science, Technology, Engineering, and Mathematics Research: Capacity-building, Community-building, and Direction-setting
  - NSF 17-055: DCL: Public Participation in Engineering Research: Water Quality
  - NSF 17-129: DCL: Support for Engaging Students and the Public in Polar Research

[2] www.youtube.com/watch?v=5ijSk-QWwjw

Goal 3: Ensure that Key Program Investments are on Track

Lead Organization: Office of Budget, Finance, and Award Management.

Goal Statement
Ensure that key NSF-wide program investments are implemented and on track.

Measure, Milestone, or Deliverable

FY	*Target*	*Result*
2017	1. Monitor the progress of the following NSF-wide investments using a common set of milestones and indicators: NSF INCLUDES, INFEWS, Risk and Resilience, and UtB. 2. Review the results with senior leaders quarterly in data-driven performance reviews.	Achieved
Trend Information		
2016	Monitor the progress of the following NSF-wide investments using a common set of milestones and indicators: NSF INCLUDES, INFEWS, and UtB.	Achieved
2015	Monitor the progress of Cognitive Science & Neuroscience, CEMMSS, CIF21, SaTC, and SEES using a common set of milestones and indicators.	Achieved
2014 (new goal)	Monitor the progress of CEMMSS, CIF21, I-Corps™, INSPIRE, SaTC, and SEES using a common set of milestones and indicators.	Not achieved (4 of 6 monitored)

Discussion
NSF instituted this goal in 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 the NSF-Wide Investments chapter of its Budget Request to Congress. Although the overall impact of these investments will not be realized for many years, tracking near-term indicators of implementation and progress can help the agency make formative changes or course corrections.

In FY 2017, NSF successfully monitored the progress of four NSF-wide investments (NSF INCLUDES, INFEWS, Risk and Resilience, and Understanding the Brain) 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 vitality and potential success, as they address whether the program is being administered as planned or whether the program is generating enough interest from the community. NSF also added the second target in FY 2017 to monitor the presentation of results to leadership.

The following were tracked quarterly in FY 2017:
- Input indicator: progress towards the investment's funding level target.
- Output indicators: solicitations issued, proposals received, awards made.
- Program-specific activities: e.g. PI meetings, workshops, and/or evaluation contract deliverables.

These measures enabled managers and leaders to quickly gauge the status of a program's implementation, interest from the scientific community, whether the review process resulted in awards in a timely manner,

and whether the program has met its internal goals for short-term outcomes. Tracking these measures over time provided managers and leaders with the opportunity to assess whether mid-course corrections were needed to improve program management and/or the overall direction of the investment.

Goal 4: Ensure that Research Infrastructure Investments are on Track

Lead Organization: Large Facilities Office, Office of Budget, Finance, and Award Management.

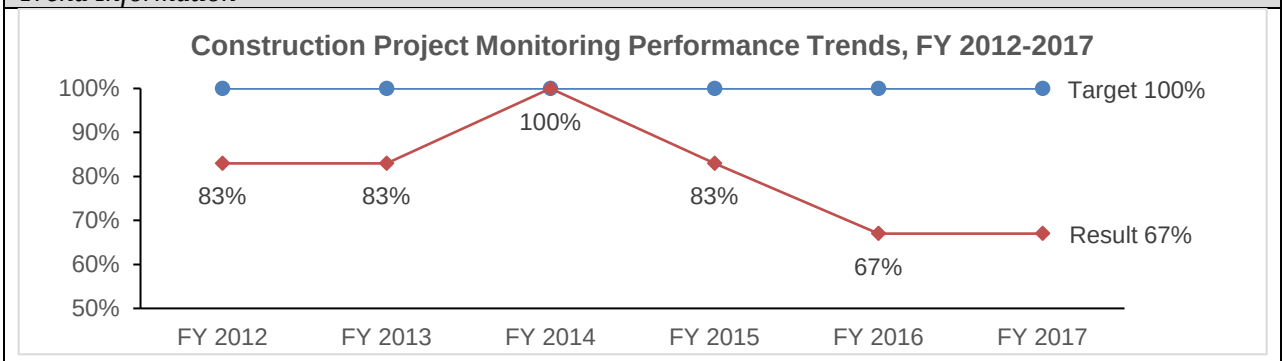
Goal Statement

Ensure program integrity and responsible stewardship of major research facilities and infrastructure.

Measure, Milestone, or Deliverable

FY	*Target*	*Result*
2017	Construction Project Monitoring: For all (100 percent) MREFC facilities under construction that are over 10 percent complete, keep negative cost and schedule variance at or below 10 percent.	Not achieved (2 of 3 projects were within cost and schedule variances).

Trend Information



Discussion

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. 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.

Two of the three projects that were over ten percent complete by the end of FY 2017 were on track. At the end of FY 2017, the Daniel K. Inouye Solar Telescope (DKIST) was 78 percent complete and the Large Synoptic Survey Telescope (LSST) was 44 percent complete. Both projects had cost and schedule variances well below the 10 percent thresholds.

Explanation of Unmet Goal

The goal was not met because of schedule issues associated with the National Ecological Observatory Network (NEON), which was 75 percent complete at the end of FY 2017. These are discussed further in the NEON section of the MREFC Chapter of this Request.

Goal 5: Use Evidence to Guide Management Decisions

Lead Organization: Office of Information and Resource Management

Goal Statement
Use evidence-based reviews to guide management investments.

Measure, Milestone, or Deliverable

FY	*Targets*	*Result*
2017	HRStat 1. Monitor the progress of three workforce initiatives of strategic importance designed to meet the objectives of the Opportunities for Action in NSF's FY 2014 and FY 2015 Strategic Reviews for Strategic Goal 3, Objective 1. 2. Develop metrics to demonstrate whether NSF met its workforce goals for transition to the new NSF Headquarters. PortfolioStat 3. NSF's IT governance boards will evaluate and prioritize proposed investments for FY 2019. 4. NSF's information technology governance boards will maintain a "green status" with investments on the Federal IT Dashboard for cost and schedule attributes (within 10 percent of target) associated with major IT investments.	HRStat 1. Achieved 2. Achieved PortfolioStat 3. Achieved 4. Not achieved
Trend Information[3]		
2016	HRStat: 2 targets PortfolioStat: 2 targets	All targets achieved
2015	HRStat: 2 targets PortfolioStat: 2 targets	All targets achieved
2014 (new goal)	HRStat: 2 targets PortfolioStat: 2 targets	All targets achieved

Discussion
HRStat and PortfolioStat are processes in which agency leaders conduct regular data-driven reviews of human resources and IT portfolio information. HR Stat targets focus on development and refinement of a human capital management dashboard for senior management use, and on the reporting of those data to management in formal meetings. Portfolio Stat targets monitor NSF's IT investment evaluation process.

HR Stat
The three monitored initiatives (Target 1) were collecting and analyzing data from exit and engagement interviews and surveys, implementation of a new leadership development program, and staff retention through the move to the new headquarters. The analysis of exit and engagement data was completed in Q3 and findings about the general workforce were shared with NSF leadership in FY 2018. NSF's new

[3] For the full target language from 2014 and 2015, please refer to the FY 2015 Performance Report in the FY 2017 NSF Budget Request (www.nsf.gov/about/budget/fy2017/pdf/56_fy2017.pdf). For full target language from 2016, please refer to the FY 2016 Performance Report (www.nsf.gov/about/budget/fy2018/pdf/59_fy2018.pdf).

leadership development program accepted candidate applications in Q4 of FY 2017, with the first cohort group to begin training in FY 2018. NSF set a goal of retaining 70 percent of the permanent workforce that was onboard at the end of FY 2015 through its move, which concluded at the end of FY 2017 (Target 2). The two-year retention rate of permanent staff through the end of FY 2017 was 86 percent.

Portfolio Stat
NSF's IT governance bodies (the Enterprise Architecture Working Group, Capital Planning and Investment Control Working Group, and the IT Resources Board) prepared the FY 2019 IT budget request and prioritized the IT investment portfolio (Target 3). To inform their investment decisions, cost and schedule data (Target 4) were presented to the governing bodies throughout the course of the fiscal year. Major investments reviewed included Enterprise Business Intelligence (BI), Public Access, and Proposal Management Efficiencies.

Explanation of Unmet Goal
At the end of FY 2017, one of the monitored project activities under Mission Support Systems had a cost variance from the target greater than 10 percent, resulting in "yellow" status for that investment and an unmet Target 4.

Goal 6: Make Timely Award Decisions

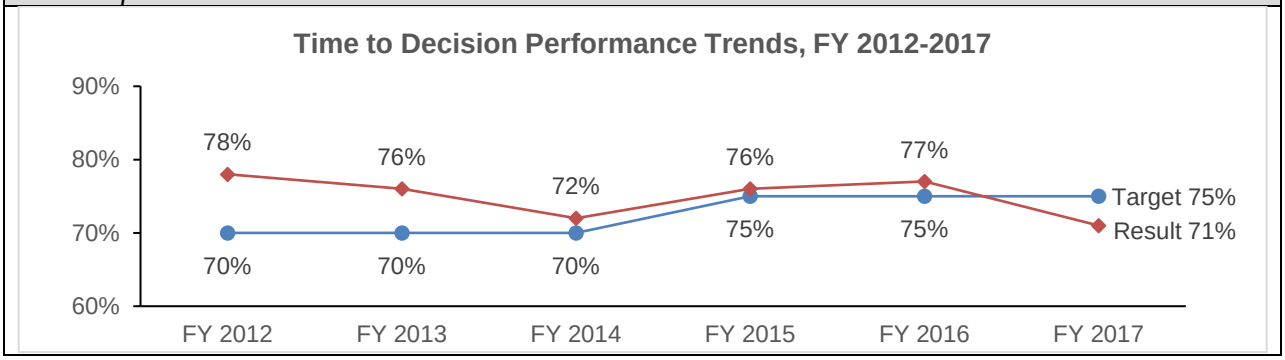
Lead Organization: Office of Integrative Activities.

Goal Statement

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.

Measure, Milestone, or Deliverable

FY	*Target*	*Result*
2017	75 percent.	Not achieved. Result = 71 percent.
Trend Information		



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 weaken the merit review process by forcing premature decisions. 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 merit review system.

Explanation of Unmet Goal

NSF staff were directed to prioritize processing award decisions ahead of decline decisions in FY 2017 to facilitate an early close-out in advance of NSF's move to new headquarters in Alexandria. The FY 2017 result reflects this delay in decline processing.

Goal Change History

In FY 2015, this target was raised from 70 percent to 75 percent to be more in line with the historical trend of achievement at or above this level. The exception of FY 2014, in which NSF exceeded the 70 percent target by a historically low margin, was likely due to Foundation-wide delays in proposal processing after the lapse in funding authority in October 2013.

Goal 7: Foster a Culture of Inclusion

Lead Organization: Office of Diversity and Inclusion (ODI), Office of the Director.

Goal Statement

Foster a culture of inclusion through change management efforts resulting in change leadership and accountability.[4]

Measure, Milestone, or Deliverable

FY	*Target*	*Result*
2017	By September 30, 2017, ODI will conduct the New IQ process with three additional organizational units. NSF will improve the three units' New IQ Self-Survey Scores by seven percent above established baseline.	No targets achieved.
Trend Information		
2016	1. By September 30, 2016, ODI will conduct the new IQ process with two NSF organizational units. 2. Improve the two NSF organizational units' New IQ Self-Survey Scores by five percent above established baseline.	No targets achieved
2015	Attain six of six essential elements of a model EEO agency, perform two compliance desk reviews under antidiscrimination laws.	Not Achieved (4/6 elements, 2 desk reviews)
2014	Attain six of six essential elements of a model EEO agency, perform two compliance desk reviews under antidiscrimination laws.	Not Achieved (5/6 elements, 0 desk reviews)
2013	Attain five of six essential elements of a model EEO agency.	Achieved
2012	Attain four of six essential elements of a model EEO agency.	Achieved

Discussion

Fostering inclusive work environments and realizing the full potential of the workforce's diversity requires agencies to employ effective management practices. The Office of Personnel Management (OPM), in partnership with the Department of Veterans Affairs, developed the New Inclusion Quotient (New IQ) in FY 2013 to measure and drive inclusive intelligence in the federal workplace. Inclusive intelligence is defined as intentional, deliberate, and proactive acts that ensure that people feel they belong and are uniquely valued.

OPM has recently developed a process to supplement use of the New IQ by using change management tools to help agencies support diversity and inclusion more fully. The expected outcome of the process is that the leaders will improve the employee engagement levels of their employees, resulting in an increase in the overall New IQ scores and corresponding FEVS scores over time. NSF recognizes that having a workforce comprised of a mix of permanent and temporary rotator staff requires targeted efforts. In addition, NSF's workforce is challenged on another inclusion front with the administrative and scientific staffs' feelings about uniqueness and belongingness. NSF anticipates that implementing the New IQ process in several of

[4] NSF has had a performance goal relating to diversity and inclusion since FY 2011. Former goals were largely focused on NSF's efforts to attain "Model EEO Agency" status. For information on earlier versions of this goal, including full goal language, refer to the FY 2015 Performance Report in FY 2017 NSF Budget Request (www.nsf.gov/about/budget/fy2017/pdf/56_fy2017.pdf)

NSF's organizational units will initiate a set of behavior changes that can become habits throughout the Foundation.

Explanation of Unmet Goal

NSF's plan to implement the New IQ in FY 2017 was delayed due to potential distractions related to the relocation to Alexandria. In FY 2018, results from the 2017 FEVS will be used as the initial pulse survey for participating units. NSF is also implementing the Workforce Inclusiveness Assessment (WIA) in FY 2018, a survey instrument that will provide a deeper dive into the culture of the agency. Data from the WIA will be used to implement additional interventions and initiatives to supplement behavioral change, which should increase sustained change within the organization.

Goal 8: Evaluate NSF Investments

Lead Organization: Office of Integrative Activities.

Goal Statement

Enable consistent evaluation of the impact of NSF investments with a high degree of rigor and independence.

Measure, Milestone, or Deliverable

FY	*Target*	*Result*
2017	By September 30, 2017, NSF will have developed seven additional evaluation frameworks. The Evaluation and Assessment Capability will work with at least seven programs (one in each directorate) to develop evaluation frameworks to be included in program management plans.	Achieved
Trend Information		
2016	By September 30, 2016, NSF will have developed three illustrative models of evaluation frameworks in the following three areas: 1. investments in the development of U.S. science and engineering human capital, 2. investments in established NSF-wide priorities, and 3. long-term strategic investments.	All targets achieved
2015 (new goal)	1. By September 2015, the Evaluation and Assessment Capability will have developed evaluation quality principles and disseminated them to all directorates. 2. These quality principles will be followed by all new evaluation projects across the agency. 3. NSF will have incorporated logic models/theory of change in the language that describes the rationale for all new programs.	No targets achieved

Discussion

The Evaluation and Assessment Capability (EAC), housed in the Office of Integrative Activities, provides NSF with the independent capacity to operate from a basis of evidence in program and policy decisions. The EAC has three multi-year goals: (1) encourage a culture of evidence-based planning and policy-making; (2) encourage increased rigor, independence, and consistency in all evaluations and assessments; and (3) develop and implement a coordinated evaluation framework.

As of the end of FY 2017, EAC has evaluation contracts underway involving all of the seven directorates (see below). Each of these seven new contract statements of work has outlined an evaluation framework. The evaluations are of cross-directorate programs, which entails some directorates being involved in more than one contract and evaluation framework. Each directorate is involved in at least one contracted study.

Program	BIO	CISE	EHR	ENG	GEO	MPS	SBE	OIA
NSF INCLUDES	o	o	X	o	o	o	o	o
Secure and Trustworthy Cyberspace		X	o	o		o	o	
Broadening Participation portfolio	o	o	o	o	o	o	o	X
EPSCoR	o	o	o	o	o	o	o	X
Centers for Chemical Innovation						X		
GeoEd			o		X			
INFEWS		o	o	X	X	o	o	o

X = lead directorate/office, o = participating directorate/office

Goal 9: Increase the Percentage of Panelists Participating in Merit Review Virtually

Lead Organization: Office of Integrative Activities, Office of the Director.

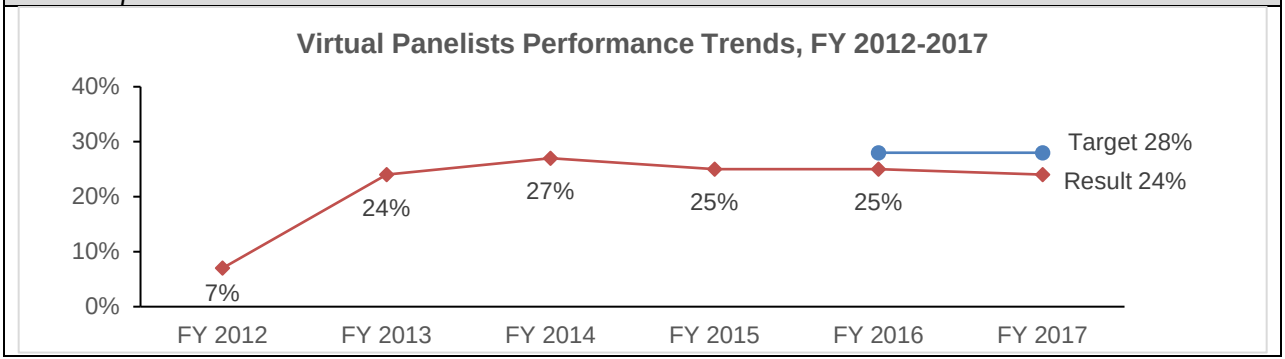
Goal Statement

Increase the percentage of proposal review panelists that participate virtually while maintaining the quality of the merit review process.

Measure, Milestone, or Deliverable

FY	*Target*	*Result*
2017	By September 30, 2017, at least 28 percent of merit review panelists will participate virtually.	Not achieved. Result = 24 percent.

Trend Information



Discussion

NSF makes extensive use of panels of reviewers to evaluate proposals, holding around 1900 panels annually. Review panels provide ample opportunity to test new methods and practices. One such practice, the use of virtual meeting technology to supplement or replace in-person panels,[5] was piloted at NSF from the early 2010s under the assumption that face-to-face panels impose a significant time burden on reviewers. NSF has had a performance goal relating to virtual panel usage since FY 2012.[6] Usage of virtual panelists peaked in FYs 2013 and 2014 due to several factors: a response to reductions in travel budgets; development of training materials; and management's encouragement to utilize virtual panels as a viable reviewer participation mechanism.

Explanation of Unmet Goal

The 28 percent target was a "stretch" level and not in line with projections for likely FY 2017 virtual panelist usage. Setting a stretch goal did not play a role in driving performance in this area.

[5] The term "virtual panelist" refers to a panel reviewer who does not travel to a common location but instead participates via teleconference, videoconference, or an online meeting technology.

[6] For four years, the goal tracked a pilot project that measured the number of "wholly virtual" panels, i.e. panels that used only virtual panelists. For more information about earlier versions of this goal, refer to the FY 2015 Annual Performance Report in the FY 2017 NSF Budget Request (www.nsf.gov/about/budget/fy2017/pdf/56_fy2017.pdf).

FY 2017 MANAGEMENT CHALLENGE PROGRESS REPORT

Background

Under the Reports Consolidation Act of 2000, NSF's Inspector General is required to summarize what it considers to be the most significant management and performance challenges facing NSF in the coming year in a memo to the NSF Director. The management challenges are identified by NSF's Inspector General and announced at the beginning of each fiscal year. In response, the Director issues a memo to acknowledge receipt of the OIG Management Challenges and to provide a report on NSF's progress and achievements made over the prior year.

The OIG's challenges, NSF's response, and NSF's progress update towards addressing previously identified challenges are included in the annual Agency Financial Report (AFR) published in November on NSF's website.[1] This section provides NSF's progress report highlighting the significant actions taken in FY 2017 on the management challenges identified by NSF's Inspector General at the beginning of that fiscal year.

FY 2017 Management Challenges

- Establishing Accountability over Large Cooperative Agreements
- Management of NSF's Business Operations: Improper Payments
- Management of NSF's Business Operations: Information & IT Resources
- Management of NSF's Business Operations: Transparency & Accountability (DATA Act)
- Management of NSF's Business Operations: Government Records
- Management of the Intergovernmental Personnel Act (IPA) Program
- Moving NSF Headquarters to a New Building
- Management of the U.S. Antarctic Program
- Improving Grant Administration
- Encouraging the Ethical Conduct of Research

FY 2018 Management Challenges

- Major Multi-User Research Facilities Management
- Business Operations Management: Improper Payments
- Business Operations Management: Transparency & Accountability
- Business Operations Management: Monitoring Subrecipients
- Business Operations Management: Government Records
- Management of the *Intergovernmental Personnel Act* (IPA) Program
- Management of the U.S. Antarctic Program
- Cybersecurity and Information Technology Management
- Encouraging the Ethical Conduct of Research

[1] www.nsf.gov/about/performance

Establishing Accountability over Large Cooperative Agreements
Lead: Branch Chief, BFA/DACS/CSB

NSF Management Overview
The Office of Inspector General (OIG) challenge relates to NSF's oversight of major facilities construction and operations cooperative agreements. The Foundation currently utilizes end-to-end oversight policies and procedures to ensure adequate stewardship over federal funds for the full project life-cycle. These activities are carried out starting with the day-to-day oversight by the Science and Engineering Directorates and the Office of Budget, Finance and Award Management (BFA) and extend through the decisional and governing responsibilities of the Office of the Director (O/D) and the National Science Board (NSB). The Major Research Equipment and Facility Construction (MREFC) Panel provides additional oversight of the design stage, which includes readiness for advancement and establishing the performance baseline for construction. Within BFA, the Large Facilities Office (LFO) develops policies and procedures related to large facilities, provides assistance to the program offices, and assures that policies, procedures, and good practices are being followed. Other BFA assurance units include the Cooperative Support Branch within the Division of Acquisition and Cooperative Support (DACS/CSB) and the Division of Institution and Award Support's Cost Analysis and Pre-award Branch (DIAS/CAP), which supports cost analysis and other pre-award activities in an advisory capacity to CSB.

NSF has been continuously enhancing its pre-award and post-award oversight of major facilities in construction and operations since June 2014. These enhancements are documented in the latest revision of the Large Facilities Manual (LFM) and internal Standard Operating Guidance (SOG). The December 2015 report by the National Academy of Public Administration (NAPA) supported NSF's use of cooperative agreements. However, the report also noted that NSF should "apply equal emphasis to increased internal management of the business practices critical to the enhanced oversight and project success" in order to bring them into balance with the science and technical aspects of oversight.

Challenge 1
Ensure adequate oversight of large facilities awards, including operations awards. Ensure that the emphasis on science results does not come at the expense of sound business practices, noting NAPA's call for equal emphasis on these two objectives.

Progress Made in FY 2017
- Revised the Large Facilities Manual (NSF 17-066) to codify American Innovation and Competitiveness Act (AICA) requirements and other newly-strengthened oversight requirements for NSF and Recipients.
- In accordance with AICA and BOAC Subcommittee recommendations, named the NSF Chief Operating Officer (COO) as the agency "Senior Accountable Official" for major facilities oversight.
- Implemented process for conducting incurred cost audits and accounting system audits led by CSB.
- Socialized new oversight requirements with major facilities community at annual Large Facilities Workshop (May 2017).
- Revised the A-123 Major Facilities Oversight Process Narrative.
- Implemented a new combined annual CSB/LFO major facilities portfolio risk assessment in draft form (June 2017) to increase engagement and collaboration between CSB, LFO, and Programs in assessing risk and selecting cooperative agreement Recipients for review activities including audits.

Future Implementation Milestones
- Finalize internal Standard Operating Guidance for joint CSB/LFO annual portfolio risk assessment (Fall 2017).

- Consider OD staffing requirements to support COO as Senior Accountable Official and periodic Directorate-level major facilities briefings with COO. (Fall 2017)

Challenge 2

Ensure access to quality Earned Value Management (EVM) data; validate the EVM report that awardees provide and require that EVM systems be certified.

Progress Made in FY 2017

- Codified and implemented Earned Value Management System (EVMS) Verification, Acceptance and Surveillance procedures (LFO SOG 17-2).
- Completed EVMS Acceptance on DKIST and LSST projects.
- Completed Verification Review of the Regional Class Research Vessel (RCRV) project EVMS.

Future Implementation Milestones

- Complete acceptance of RCRV project EVMS prior to initiating physical ship construction (Spring 2018).
- Conduct EVMS Verification Review on the Antarctic Infrastructure Modernization for Science (AIMS) project (December 2017).

Challenge 3

Implement new policy changes based on NAPA and OIG recommendations to ensure effective oversight.

Progress Made in FY 2017

- Closed nearly 50 of the 55 OIG recommendations (90 percent) related to oversight of major facilities dating back to 2012.
- Received BOAC NAPA Implementation Subcommittee Report and began consideration/implementation of recommendations (March 2017).
- Initiated BOAC Subcommittee on Cost Surveillance to assess NSF's strengthened policies and procedures (June 2017).
- Developed and implemented revised internal policies and procedures related to "fee" (July 2017).

Future Implementation Milestones

- Develop and implement new internal policies and procedures related to management reserve (Fall 2017).
- Implement formal Lessons Learned program (preparing pilot for launch at Large Facilities Workshop; May 2018).
- Enhance documentation and formalization of NSF Communities of Practice (PO Forum Charter; Fall 2017).
- Implement NSF-wide "Core Competency" staff requirements (Standard Operating Guidance) related to major facilities oversight (Fall 2017).
- Strengthen MREFC Panel oversight role (full life-cycle) based on BOAC subcommittee recommendations (Pilot new "Major Facilities Panel" concept in Q1 CY 2018).
- Revise and implement internal policies and procedures related to NSF cost analysis, and independent cost estimate reviews based on American Innovation and Competitiveness Act (AICA) requirements (Fall 2017).

Management of NSF's Business Operations: Improper Payments
Lead: Division Director, BFA/DFM

NSF Management Overview

NSF Management does not consider improper payments to be a significant risk to NSF's mission, programs, or operations. In May 2017 the NSF OIG issued a report on NSF's compliance with the Improper Payment Elimination and Recovery Act (IPERA) requirements for FY 2016. The OIG concluded the NSF complied with the requirements of IPERA and had addressed all recommendations from the previous OIG report. This was the second consecutive report finding NSF in compliance with IPERA reporting requirements. The May 2017 OIG report had no recommendations and no resolution tracking requirements. The two reports validate that NSF has taken the steps necessary to demonstrate compliance and effectiveness in the agency's implementation of IPERA. In summary, NSF has:

- Demonstrated strong commitment and top leadership support to incorporate risk management concepts into business processes and management functions;
- Ensured that NSF has the people and resources to effectively comply with IPERA by assigning a senior staff associate responsible for coordinating and integrating risk management and program integrity activities;
- Executed an action plan that addressed the root cause of the IPERA reporting issue, implemented solutions, and completed all OIG recommendations;
- Established processes to monitor and validate the effectiveness and sustainability of the corrective measures; and
- Incorporated corrective measures into policy and process documentation.

The milestones listed below describe NSF's efforts to maintain and monitor IPERA compliance.

Challenge

i) Address significant limitations in NSF's analysis of six of the nine White House Office of Management and Budget (OMB) risk factors, and ii) improve assessment of NSF payments to employees, e.g. payroll testing and interviewing HRM regarding administering salary and benefits. OIG has made eight recommendations to strengthen NSF IPERA risk assessments.

Progress Made in FY 2017

- Developed and published standard operating guidance (SOG) BFA 2017-1 on November 10, 2016 for improper payments risk reviews incorporating the nine IPERA risk factors and additional considerations from the OIG review report.
- Completed an improper payments risk review for FY 2016. The risk review included input from subject matter experts for grants, contracts, charge cards, and payments to employees.
- Received OIG inspection of the FY 2016 risk review, which found NSF in compliance with the requirements of IPERA.

Future Implementation Milestones

- Update the improper payments risk review SOG by providing additional details for the process to obtain and group fiscal year disbursements and refine the evaluation of the SME input on the nine IPERA risk factors. Publish the update by November 1, 2017.
- Complete an improper payments risk review for FY 2017 outlays per the SOG (planned for early FY 2018).
- Plan and conduct an improper payments risk assessment for FY 2018 by December 31, 2018.

Management of NSF's Business Operations: Information & IT Resources
Lead: Division Director, OIRM/DIS

NSF Management Overview
NSF is aware that the availability of IT resources and security posture of its information technology (IT) systems is of critical importance to the Foundation's ability to carry out its mission, particularly in a year in which NSF is relocating its headquarters. NSF employs tools and technology in its Information Security Continuous Monitoring (ISCM) program to continuously monitor the network availability and security posture. As part of the ISCM program NSF implemented the Department of Homeland Security (DHS) Continuous Diagnostic and Mitigation (CDM) tools and technology to monitor the network. The IT security program is evaluated yearly by an independent organization in accordance with the Federal Information Security Management Act (FISMA). NSF has been proactive in reviewing security controls and identifying areas to strengthen the program, including incorporation of information gained and lessons learned from the FISMA report.

The Office of Polar Programs (OPP) U.S. Antarctic Program (USAP) proactively monitors its network to ensure compliance with security requirements. OPP allocates appropriate resources to the USAP IT security program to address information security requirements and FISMA review findings.

Challenge
(i) Before the move in FY 2017, NSF should increase the timing and robustness of IT testing, and after the move, NSF should ensure agency information and IT resources remain available, secure, and complete. Efforts may be assisted by using information security continuous monitoring (ISCM) strategies.
(ii) Allocate appropriate resources to correct IT weaknesses related to the U.S. Antarctic Program (USAP) and ensure the systems and information are adequately protected.

Progress Made in FY 2017: NSF Move
- Continued to maintain a detailed move plan for IT systems and services with comprehensive IT applications testing and validation, including user testing, as IT services are transitioned to the new headquarters building.
- Completed the electronic move of applications, databases and servers, and validation testing successfully in June 2017.
- Completed the physical server move and validation testing successfully in July 2017.
- Utilized information security continuous monitoring (ISCM) resources, tools, and strategies to ensure continued availability of services and applications during the stabilization period following NSF's staff moves in late summer/early fall 2017.

Progress Made in FY 2017: U.S. Antarctic Program (USAP)
The Office of Polar Programs (OPP):
- Completed a thorough review of USAP IT security program controls to ensure compliance with federal guidance and risk management and adequacy of risk management plans.
- Allocated appropriate resources to the USAP IT security program to address information security findings identified in the annual FISMA review.
- Documented redundancy capabilities to IG auditors to demonstrate resiliency of the USAP network and re-evaluate a longstanding finding to close the original issue.
- Initiated a disaster recovery plan to document actions in the event of a contingency. OPP is also planning to complete a business impact analysis to validate their approach to service recovery.

Future Implementation Milestones

- Continue to monitor the availability, responsiveness, and security of agency IT resources during and after the move to the new headquarters, utilizing information security continuous monitoring (ISCM) strategies in support of these activities.
- Continue to address identified IT security weaknesses through USAP program funding.

Management of NSF's Business Operations: Transparency & Accountability (DATA Act)
Lead: Chief Financial Officer, Senior Accountable Official

NSF Management Overview

NSF successfully implemented the Digital Accountability and Transparency Act (DATA Act) on April 28, 2017. The DATA Act is a government-wide initiative led by OMB and the U.S. Department of Treasury (Treasury) to standardize and publish the federal government's wide variety of reports and data compilations related to spending: financial management, payments, budget actions, procurement, and assistance. NSF senior agency officials were aware of the Act early on, and when the legislation passed, NSF moved immediately to leverage its resources to prepare for implementation. At NSF, the DATA Act has been a cross-agency initiative with early leadership from the NSF Office of the Director supported by subject matter experts in BFA and the Office of Information and Resource Management (OIRM) for implementation support, and an internal governance structure that included an executive-level steering committee, a DATA Act Working Group (DAWG) and a DATA Act Project Management Office (PMO). The Senior Accountable Official (SAO) is presently the Acting Chief Financial Officer (CFO) and Office Head of BFA.

Additionally, NSF collaborated with its OIG around stewardship and supported the OIG in its efforts to publish a DATA Act readiness review by November 2016. OIG staff have consistently had access to all DATA Act-related materials through meetings, interviews and the DAWG SharePoint site. NSF implemented all of the OIG project management-related recommendations and took steps to address ongoing OIG concerns around human resources planning.

Government-wide, NSF staff have represented the agency in connection with DATA Act-related activities, including the Financial Assistance Committee for E-government (FACE); the Data Standards Committee, an Executive-level interagency group representing the budget, financial assistance and procurement communities charged with making recommendations on issues of government-wide data standardization; the Procurement Committee for E-government; and numerous additional DATA Act-related workshops, meetings and small-group strategy sessions with OMB, Treasury, and other CFO Act agencies. These collaborations have been key to NSF's DATA Act implementation success.

NSF success is also attributable to its risk-based approach to implementation. The agency actively took steps to identify and mitigate risks and evaluated multiple approaches to ensure on time compliance. No major system changes were required in order for NSF to meet the deadline. Going forward, the agency will work towards operationalizing the DATA Act submission and will continue its successful and on time implementation. The DAWG will continue to foster strong internal, executive-level and government-wide communication, as needed, and will continue to support the OIG as needed in its upcoming DATA Act audit scheduled for publication by November 2017.

Challenge

Achieve successful implementation of the DATA Act despite evolving federal guidance, the late release of Treasury's production-ready broker, the late release of iTRAK software patches, limited available agency FTE, the potential that NSF's relocation may impact DATA Act activities, and the lack of a clear funding source for NSF's DATA Act implementation efforts.

Progress Made in FY 2017

- Developed and implemented a Corrective Action Plan in response to OIG Readiness Review.
- Developed human resources tracking document maintained on SharePoint in response to ongoing OIG DATA Act staffing concerns.
- Generated and tested Award Submission Portal (ASP) data file per Treasury's evolving specifications from FY 2016 Q3 through FY 2017 Q1.

- Developed a business intelligence solution for generating ASP submission and correction files using the award data from the Awards system and System for Award Management (SAM) information from iTRAK data extracts, for submitting NSF's financial assistance data to USASpending.gov.
- Complied with ASP submission requirements to USASpending.gov starting with January 2017 data submission.
- Implemented initial Oracle patch for award attributes and modified award system interfaces with iTRAK to populate the following attributes: Procurement Instrument Identifier (PIID), Parent Award Identifier (PAID), Federal Award Identification Number (FAIN), and Unique Record Identifier (URI).
- Uploaded financial assistance and procurement files to populate the award attributes in iTRAK.
- Implemented Oracle patch for main DATA Act functionality to configure mappings and generate files that are required to be submitted to Treasury's production-ready broker (Broker) for subsequent public reporting of financial data. [These files are: file A (Appropriations Account Data), B (Object Class and Program Activity Data), and C (Award Financial Data).]
- Developed custom solution (alternative, back-up approach) that leverages existing iTRAK reports and NSF tools to generate files A, B, and C, and reconciliation reports to mitigate risk of not having the Oracle patches ready for DATA Act compliance by May 2017.
- Developed Program Activity mappings to crosswalk iTRAK file B data with Program Activity Codes from the Program and Financing (P&F) Schedule in the President's Budget Appendix.
- Generated files A, B, and C using the custom solution.
- Performed Broker testing by uploading agency-generated files A, B, and C.
- Performed Broker testing by extracting data for files D1 (Award and Awardee Attributes for Procurement), D2 (Award and Awardee Attributes for Financial Assistance), E (Additional Awardee Attributes), and F (Sub-award Attributes).
- Performed Broker testing in order to validate files A through F to facilitate certification of NSF's data.
- Implemented custom solution to generate files A, B, C, and reconciliation reports, and submitted files A - F prior to the DATA Act compliance date of May 2017.
- Achieved compliance with May 2017 DATA Act implementation deadline.
- Received the Secretary's Certificate of Appreciation from the U.S. Department of the Treasury in recognition of NSF's outstanding commitment to collaboration while implementing the DATA Act on June 28, 2017.
- Documented standard operating procedures for generation, certification, and submission of files A- F.
- Engaged with OIG and responded to the OIG Provided by Client (PBC) List with requested materials in support of the OIG DATA Act audit report to be published in November 2017.
- Provided agency source data to Government Accountability Office (GAO) and answered questions to support GAO's mandated government-wide DATA Act Data Quality Review; NSF data that had been posted on beta.USASpending.gov was included in the sample of government-wide data GAO pulled to conduct its review.

Future Implementation Milestones

- Transition financial assistance (file D2) reporting from the existing ASP to comply with Treasury's DATA Act Information Model Schema (DAIMS) v1.1 and Financial Assistance Broker Submissions (FABS) scheduled in September 2017 and DAIMS v2.0 in Spring 2018.
- Continue to use the custom solution to generate files A, B, C, and reconciliation reports, and submit files A – F on a quarterly basis until a decision is made on how to move forward with the Oracle patches.
- Continue to refine and document all DATA Act-related business processes and Standard Operating Procedures (SOPs).
- Continue to provide information to GAO and OIG in connection with DATA Act reviews.

Management of NSF's Business Operations: Government Records
Lead: Division Director, OIRM/DAS

NSF Management Overview
In 2012, OMB and the National Archives and Records Administration (NARA) issued a directive, OMB Memorandum M-12-18, Managing Government Records. This directive is consistent with a 2011 Presidential Memorandum requiring Federal agencies to reform the policies and practices for the management of physical records and to provide a framework for the management of electronic records.

GAO subsequently issued Report 15-339, dated May 14, 2015, "Information Management: Additional Actions Are Needed to Meet Requirements of the Managing Government Records Directive". NSF formulated a Corrective Action Plan (CAP) in response to the GAO report and is on schedule to meet all the planned actions enumerated in the CAP. Additionally, NSF hired a dedicated professional in its Records Management Section to oversee implementation of the CAP and efforts associated with the relocation of NSF's headquarters.

Challenge
Ensure compliance with the National Archives and Records Administration's 2012 directive to take specific reform actions by designated dates. In particular, meet deadlines associated with relocating NSF's headquarters by: (i) ensuring appropriate training and guidance for employees; (ii) updating NSF's record retention schedules to classify electronic records as official agency records; and (iii) adhering to established agency schedule to review, scan, and digitize its paper records.

Progress Made in FY 2017
- Revised the records management training course to comply with NARA Bulletin 2017-01, Agency Records Management Training Requirements in June 2017. The revised course will be required training for all staff on an annual basis.
- Classified the Office of Inspector General's (OIG) electronic records as official records per the OIG Records Schedule (DAA-0307-2016-0003) as approved by the Archivist of the United States on January 6, 2017.
- Scanned over 7,000 permanent and temporary records from August 2016 to August 2017 to reduce the footprint of hardcopy files ahead of NSF's move to its new headquarters.

Future Implementation Milestones
- Update the records management policy that is dated October 1988 to comply with current NARA guidance and 36 CFR Chapter XII, Subchapter B - Records Management, and issue by March 31, 2018.
- Complete an agency-wide records inventory by the end of FY 2018 to provide a foundation for developing file plans and additional records schedules as needed.
- Create an online training for the Electronic Records Management System (ERMS) and make it available in LearnNSF by December 31, 2017.
- Destroy all records at the Federal Records Center (FRC) that have met their disposition date and are no longer required by the agency by the end of FY 2018, and continue to scan records to put in ERMS. Both activities will reduce annual storage costs at FRC.
- Update remaining record schedules and classify electronic records as official agency records, and get approvals from the Archivist of the United States by the end of FY 2019.

Management of the IPA Program
Lead: Division Director, OIRM/HRM

NSF Management Overview
NSF provides the opportunity for scientists, engineers, and educators to rotate into the Foundation as temporary Program Directors, advisors, and leaders. Rotators bring fresh perspectives from across the country and across all fields of science and engineering supported by the Foundation, helping influence new directions for research in science, engineering, and education, including emerging interdisciplinary fields. In fact, many of these rotators remain involved in their professional research while working at NSF through participation in the Independent Research/ Development (IR/D) program (managed by the NSF IR/D Council). Because NSF supports fundamental research at the frontiers of science and engineering, NSF relies on the synergy of federal employees and temporary staff for a constant infusion of new knowledge into the broad understanding of science, and a continuously improving structure of systematic and rigorous merit review. Federal and rotating staff and executives partner to ensure NSF stays abreast of and supports the very latest research ideas while ensuring stability and continuity of operations and strong stewardship and accountability of taxpayer resources. For example, federal Deputy Assistant Directors (DAD) provide continuity for rotating Assistant Directors (AD).

In April 2016, NSF Director France A. Córdova announced the establishment of a Steering Committee for Policy and Oversight of the IPA Program (IPA Steering Committee). The Steering Committee serves as the primary body for considering IPA-related policies, oversees common approaches to budgeting and implementation of the IPA program, and champions the effective use of IPAs, identifying the benefits they bring the agency and the actions taken by the agency to mitigate risks and costs. The IPA Steering Committee is Chaired by the Chief Human Capital Officer (CHCO) with membership consisting of the Chair of the NSF Executive Resources Board (ERB) and the Independent Research and Development (IR/D) Council; the Head of the Office of Diversity and Inclusion, and four at-large members, including two IPAs.

In June 2017, NSF's OIG issued the audit report, "NSF Controls to Mitigate IPA Conflicts of Interest." The report concluded that NSF had "implemented internal controls to identify and mitigate IPA conflicts of interest." NSF formulated a corrective action plan in response to the OIG's recommendations to strengthen and add additional controls.

Challenge
The challenges that come with NSF's Intergovernmental Personnel Act (IPA) program are as follows: i) Almost constant turnover in staff at NSF, especially in senior leadership positions; ii) Due to IR/D activities, the amount of time IPAs spend at their home institutions raises questions about their ability to fulfill their responsibilities at NSF and be fully engaged in the agency's mission; iii) It is critical that strong controls be in place to identify and mitigate IPA conflicts of interest; and iv) NSF's reliance on IPA's comes with a high cost. The number of IPAs and their cost (i.e., salaries, benefits, travel) have increased in the last 3 years. IPAs are not subject to federal pay and benefits limits.

Progress Made in FY 2017
- Issued a memorandum to NSF staff, including IPAs, in March 2017 reminding them of the importance of high ethical standards (Staff Memorandum OD 17-03); also issued a notice to supervisors, in August 2017, reminding them of their ethics responsibilities, specifically the responsibility to ensure the compliance of their subordinates, including IPAs, with the ethics rules (Staff Memorandum OD 17-17).
- Initiated a pilot requiring 10% cost sharing by the IPA's home institution of the IPA's academic-year salary and fringe benefits (per NSF Bulletin 16-11), which applies to all new IPA agreements initiated in FY 2017, including those for executive- and program-level staff. Additionally, NSF will no longer provide for Lost Consulting payments.

- Published a revised IR/D Guide in January 2017, via the IR/D Council, that includes guidance limiting NSF payment of IPAs' IR/D travel to their home institutions to 12 trips per year. The guidance encourages IPAs to combine other NSF official business and/or telework with these trips to get the most efficient use of those travel dollars.
- Designed and began data collection for an evaluation, initiated in the Office of Integrated Activities (OIA), to determine the cost implications associated with the 10% cost-sharing pilot and determine to what extent the policy change impacts NSF's ability to recruit strong IPAs.
- Closed the sole open OIG audit recommendation related to IPA costs.
- Reviewed and updated core policies relating to IPAs in the NSF Personnel Manual.
- Strengthened communication and implemented regular meetings between the Chief Operating Officer and Deputy Assistant Directors to reinforce and support leadership continuity.
- Implemented a process for Chief Operating Officer review and AD/DAD discussion of IPA salary cases that exceed the Senior Executive Service cap.

Future Implementation Milestones

- Develop an Integrated Workforce Strategy as part of NSF's Agency Reform activity. This workforce framework will aid in identifying the balance of Federal and Rotator Executive Resources within the Research Directorates. An initial draft will be submitted to the IPA Steering Committee in October 2017.
- Deliver the cost sharing pilot evaluation to the IPA Steering Committee in November 2017.
- Clarify and improve enforcement of policies on the submission of preliminary and new proposals while serving as an IPA and designation of a substitute negotiator for proposals submitted until one year after departure.
- Implement an electronic separation clearance process that tracks completion of exit interviews where separating staff will acknowledge their responsibility for being familiar with post-employment restrictions.

Moving NSF Headquarters to a New Building
Lead: Senior Relocation Project Officer, OIRM/OAD

NSF Management Overview
NSF began to occupy its new location in Alexandria, Virginia in August 2017 and is well-positioned to vacate its Arlington, Virginia locations by December 31, 2017. The NSF Relocation Office (NRO) is leading this effort and is charged with ensuring a successful outcome to NSF's expiring lease effort through the delivery of a next-generation NSF headquarters facility. NRO's mission is accomplished through input of the entire NSF staff through Directorate liaisons, the American Federation of Government Employees (AFGE) Union-Local 3403, the agency Relocation Executive Advisory Group (REAG), the General Services Administration (GSA), and other stakeholders to the project.

Through demonstrated leadership and disciplined project management, NRO continues to make significant progress in key areas to ensure project success and mitigate risks relating to scheduling delays, union negotiations, and records management. NRO has developed a detailed relocation plan and has also taken concrete steps to align the project's budget with its estimated cost.

Groundbreaking for the new NSF Headquarters was in January 2014, construction on the interior space began in April 2016, and the building was substantially complete to begin occupancy by NSF staff in August 2017. The new building will prominently reflect NSF's role nationally and internationally in the science and engineering community.

Challenge
Ensure NSF has a complete, accurate, and updated schedule to meet the move deadlines before leases on the existing buildings expire at the end of 2017.

Progress Made in FY 2017
- Added NSF Relocation to the Director's Watch List in March 2017 and met with the Director six (6) times.
- Relocated the NSF data center and network from Arlington to Alexandria successfully prior to the relocation of staff.
- Installed the majority of NSF personal property designed for the new building (e.g. furniture, audio-visual equipment, information technology, and security equipment) prior to the relocation of staff.
- Prepared agency staff for the relocation:
  - Conducted numerous town halls and education sessions to advise staff on features and services in the new building as well as detailed packing guidelines and procedures for the physical move.
  - Created a dedicated relocation website on the NSF intranet that included answers to frequently asked questions, completed floor plans, transportation options to the new headquarters, neighborhood information, etc.
  - Shared multiple informational articles and videos on the relocation website and in NSF's weekly newsletter to keep staff apprised of all relocation-related news and updates.
- Reached agreement with our union partners on key issues (e.g., parking, physical relocation) during the third and final phase of negotiations.
- Substantially completed construction of the interior space. City of Alexandria has conducted its final inspections of the building.

Future Implementation Milestones
- Complete the relocation to Alexandria successfully.
- Vacate and return Stafford I & II and the Rosslyn location to the landlords before December 31, 2017.

Management of the U.S. Antarctic Program
Lead: Division Director, GEO/PLR

NSF Management Overview
Through the Office of Polar Programs in the Directorate for Geosciences, NSF funds and manages the U.S. Antarctic Program (USAP), which supports United States' research and national policy goals in the Antarctic. Given the remote location, extreme environment, and the short period of time during which the continent is accessible, significant challenges exist for ensuring the availability of necessary logistics, operations, and science support. There are also unique and internationally-linked environmental, health, and safety issues present at the remote location. In exercising its management responsibilities, NSF relies on internal staff with the requisite expertise as well as a network of contracted support and federal agency partners. Periodically, the program is reviewed by external panels of experts.

Challenge 1
Ensure a successful transition from Lockheed Martin to Leidos as the Antarctic Support Contractor (ASC) together with their respective subcontractors by having strong cost controls to protect the government against unwarranted increases in ASC costs during a period of reorganization and mergers.

Progress Made in FY 2017
- Held routine executive meetings with Lockheed Martin leadership to understand the strategic rationale for the transition to Leidos and the impact to the Antarctic Support Contract (ASC).
- Started implementing the Novation Agreement processed by the Defense Contract Management Agency (DCMA) as the cognizant Federal Agency, which concluded that restructuring was in the best interest of the government.
- Monitored Leidos' operations on legacy Lockheed Martin systems. The Accounting System, Estimating System, Material Management and Accounting System, Purchasing System, and Property System were approved by DCMA in a letter dated August 25, 2016.
- The successful transition from Lockheed Martin to Leidos through a Reverse Morris Trust has resulted in decreased costs for ASC.

Future Implementation Milestones
- Continue to monitor the ongoing transfer of business systems from Lockheed Martin to Leidos, which is expected to be complete by January 1, 2018. Subsequently, the Leidos DCMA Divisional Administrative Contracting Officer will review and approve Leidos business systems.
- Continue to monitor invoices, Annual Program Plans, business system reviews (accounting, estimating, purchasing systems), indirect rates and financial reporting for the USAP contractor to ensure strong cost controls continue with the new entity.

Challenge 2
Ensure modernization of McMurdo Station and upgrades to Palmer Station as they proceed to construction projects, capitalizing on lessons learned from NSF's large facility work as appropriate.

Progress Made in FY 2017
- Continued progress on the 2012 Blue Ribbon Panel (BRP) recommendations, including investment in lifecycle acquisitions and infrastructure upgrades.
- Addressed major infrastructure upgrades recommended by the BRP report for McMurdo Station through the following design efforts:
    - Completed designs for the Antarctic Infrastructure Modernization for Science (AIMS) project, including Core Facility and Utilities packages, and presented the designs to the MREFC Preliminary Design Review (PDR) Panel.

  - Completed designs of the Vehicle Equipment/Operations Center using NSF Research and Related Activities Funding.
  - Continued design on the Information Technology & Communications (IT&C) Primary Operations Center, Lodging, and Palmer Pier Replacement Projects.
  - Completed presentation to the National Science Board (NSB), which resulted in the NSB's recommendation that the NSF Director or her designee include the AIMS project in a future budget request.
- Issued a Sources Sought Notice on FBO.gov to apprise potential offerors on the AIMS project (https://www.fbo.gov/index?s=opportunity&mode=form&id=b1177342be2eaaf94c01809ece0e1854&tab=core&_cview=0).
- Continued internal coordination with LFO in order to leverage institutional knowledge pertaining to previous large facilities work, including best practices and considerations outlined in NSF's Large Facilities Manual (NSF 17-066).

Future Implementation Milestones
- Initiate and complete necessary solicitation efforts for individual AIMS components.
- Complete designs for IT&C Primary Operations Center.
- Conduct advance planning/design for Ross Island Earth Station (RIES).
- Prepare for AIMS Final Design Review (FDR), anticipated in Q1 of FY 2019.
- Continue to update the long range capital plan to include lifecycle and real property investments for all Antarctic locations.

Challenge 3

Continue to provide oversight of costs incurred for medical expenses under the ASC and its subcontractors by providing guidance on what expenses are eligible for reimbursement.

Progress Made in FY 2017
- Improved USAP participant guidance for Physical Qualification (PQ) exams by better stating required tests and warning of non-reimbursable costs.
- Reviewed PQ requirements, along with the contractor, during the May 2017 medical retreat in preparation for the June 2017 medical review panel meeting.

Future Implementation Milestones
- Continue to review and modify PQ requirements, including during the annual medical review panel meetings
- Receive contractor assessments of PQ non-reimbursable charges and reports of participant confusion with PQ process in order to guide continuous improvement.

Challenge 4

Continue to provide investment in the oversight of both small and larger invoiced costs from ASC until NSF is better assured of the USAP contractor's internal controls.

Progress Made in FY 2017
- Continued to apply invoice processing in accordance with the "Guidance and Instructions for Invoice Review and Processing" SOP.
- Requested periodic, full listings of materials/items of less than $5,000 for review.

Future Implementation Milestones
- Continue to apply invoice processing in accordance with the "Guidance and Instructions for Invoice Review and Processing" SOP.

- Perform a "deep dive" review of a random 10% of invoices.
- NSF will continue to evaluate Leidos subcontractor billing processes. Leidos mechanisms to monitor and validate the accuracy of subcontractor billing and subsequent billing to NSF include random sampling, subcontractor rate analysis and bi-weekly and monthly billing reconciliation.

Challenge 5

Continue to coordinate with the ASC to identify and control risks (e.g., loss or damage) of Antarctica-bound inventory stored and maintained at Port Hueneme, California; Punta Arenas, Chile; and Christchurch, New Zealand.

Progress Made in FY 2017

- Conducted two detailed route-cause analyses in response to early FY 2017 failures, followed by process improvements. NSF directed the ASC to develop reports on the damaged science equipment and mishandled science samples explaining how and why the damage occurred, and to implement corrective actions to avoid such damage in the future. NSF then approved the action plans, and monitored contractor activity for effectiveness.
- Modified contract policy so that going forward senior ASC management will be directly involved in all high value-science sample shipments to ensure minimum risk. Final approval for shipment must come from the senior transportation manager.
- Ensured that appropriate mitigation for the risk of loss or damage would be implemented by November 2016.

Future Implementation Milestones

- Direct NSF's annual assessment of ASC performance, which will identify cargo failures and contractor responses. Emphasis will be placed on opportunity costs of mishandled science samples and replacement costs of damaged inventory. Penalties will be considered in the contractor award fee.
- Continue to monitor the next surge of cargo shipments, which began in August 2017 and will continue through February 2018. Weekly NSF-led transportation meetings will continue to emphasize ASC responsibility to protect government property and science samples.

Improving Grant Administration
Lead: Division Director, BFA/DIAS

NSF Management Overview
As of June 30, 2017, the NSF award portfolio consisted of 41,877 active awards, representing $26.6 billion in obligated funds to 2,983 unique awardees. NSF accountability efforts span six award stages (proposal submission, merit review, pre-award financial review, post-award monitoring, award closeout, and audit follow-up) to ensure financial capability and accomplishment, non-financial administrative and programmatic compliance, and research performance. The foundation of NSF's accountability efforts is its suite of policy and procedural documents that incorporate federal regulations, legislative mandates, and agency-specific requirements; the translation of policies and procedures into business rules that are enforced through NSF's information technology systems; and a risk-based approach to financial and administrative monitoring. Baseline monitoring activities, which are conducted on most awards through standard, recurring, and automated processes, focus on post-award administration and financial transactions to identify exceptions and potential issues that may require scrutiny through advanced monitoring. Financial baseline monitoring is used to identify potential anomalies, inaccurate expenditure reporting, or evidence of a possible misunderstanding of, or non-compliance with, federal cash management requirements and/or NSF guidelines.

In FY 2017, major accomplishments in strengthening grant administration included: (1) implementation of the restructuring of NSF's Cost Analysis and Audit Resolution Branch into two separate units focused on pre- and post-award functions to better address continuing growth in complexity and breadth of oversight functions; (2) continuation of a multi-year effort to modernize NSF's Award System, which included implementation of functionality that enables program staff to seamlessly manage $860 million in funding increments to over 4,600 awards; and, (3) successfully piloting a new tool, Targeted Review Assessments (TRAs), that allows NSF to quickly assess areas of grants management and compliance, and to provide targeted necessary business assistance to the awardee community.

Challenge 1
Implement controls over spending of grant funds that ensure transparency and accountability without unduly adding to the administrative burden of awardees and federal program officers.

Progress Made in FY 2017
- Fully implemented inter-agency Research Terms & Conditions (RTCs), in accordance with requirements of OMB's *Uniform Administrative Requirements, Cost Principle, and Audit Requirements for Federal Awards (Uniform Guidance).* RTCs create greater consistency in the administration of federal research awards and reduce awardee administrative burden.
- Refined and conducted FY 2017 baseline award monitoring of financial transactions across NSF's grant portfolio; explored feasibility of strengthening integration of baseline and advanced monitoring activities; and initiated baseline monitoring review of grants with little or no NSF's significant financial activity.
- Continued Federal Awardee Performance and Integrity Information System (FAPIIS) implementation. Issued the final Standing Operating Guidance for Pre-Award Reviews and Posting Terminations to ensure compliance in accordance with the *Uniform Guidance.*

Future Implementation Milestones
- For FY 2018, NSF will initiate a fraud risk assessment within the grants program, continue to refine its Enterprise Risk Management (ERM) risk profile, and complete an improper payments risk assessment. As part of the fraud risk assessment NSF will explore opportunities to leverage data analytics to enhance monitoring activities and grants administration.

- Continue to implement legislative requirements: 1) standardization and publishing of reports and data on federal spending under the DATA Act; and 2) reporting NSF information on undispersed balances in grant awards expired more than two years under the Grant Oversight and New Efficiency (GONE) Act.

Challenge 2

Take additional steps to oversee awardees that fall below the OMB Uniform Guidance Single Audit threshold of $750,000 in total federal expenditures.

Progress Made in FY 2017

- Continued to fully implement the *Uniform Guidance* that raised the single-audit threshold to avoid duplication of effort across agencies, as well as created cost/time efficiencies and reduced administrative burden for awardees and the federal government. As intended under the *Uniform Guidance,* NSF focused efforts on organizations exposed to higher risk, reviewing as appropriate awardee records required for review by federal agencies, pass-through entities, and GAO throughout a broad array of pre- and post-award oversight efforts, especially advanced and baseline award monitoring activities.
- Conducted annual NSF Risk Assessment to assess level of risk associated with awardees' portfolios to identify institutions for advanced monitoring; complemented findings with results from prior institution-based oversight activities as well as concerns identified by NSF program offices and the OIG. Continued emphasis on institutions with $2 million to $15 million in NSF funds that have historically demonstrated more difficulty in administering NSF awards than those managing larger award portfolios.
- Conducted risk assessments of single audits for institutions receiving NSF funds to identify institutions with highest risk for more effective utilization of resources.

Future Implementation Milestones

Assess and, as needed, refine risk criteria (i.e., award-specific, institutional, prior monitoring activities and results, award administration, and program feedback) used in the annual NSF Risk Assessment to identify those awardees managing the highest risk portfolios, and targeting those institutions for advanced monitoring activities.

Challenge 3

Ensure prime grant recipients provide oversight of sub-recipients' incurred cost submissions to demonstrate costs are allowable, fair and reasonable.

Progress Made in FY 2017

- Piloted Targeted Review Assessment (TRA) methodology to assess compliance of 29 prime awardees' oversight of subrecipients per OMB *Uniform Guidance* (2 CFR 200.331). Provided feedback to awardees where minor issues were noted; required formal corrective actions for two awardees with more significant issues.
- Provided the OIG with a summary of TRA findings; shared 10 TRA results and files with the OIG to inform its audit of NSF oversight of prime awardees with subrecipients in accordance with the *American Innovation and Competitiveness Act*.

Future Implementation Milestones

- Review advanced monitoring subaward module for opportunities to upgrade assessment protocols based on TRA findings and *Uniform Guidance* requirements; as appropriate, incorporate feedback from OIG audit of NSF to enhance the subaward module for future oversight activities.
- Update DIAS fact sheet on subrecipient monitoring with links to *Uniform Guidance* requirements for

pass-through entities (including risk assessment of all subrecipients) consistent with above bullets.

- Continue to require prime awardees to take corrective actions in cases requiring development and/or implementation of internal controls for subaward close-out, conduct of subrecipient risk assessments, and review of single audit reports ensuring compliance with OMB *Uniform Guidance*.

Encouraging the Ethical Conduct of Research
Lead: Office of the Assistant Director, SBE/OAD

NSF Management Overview
The responsible and ethical conduct of research is critical to ensure excellence, as well as public trust, in science and engineering. In accordance with Section 7009 of the America COMPETES Act (ACA) (42 U.S.C. §1862o–1) and recognizing the importance of ethical conduct of research, NSF requires that each institution submitting a proposal certify, under penalty of perjury, that it has a plan to provide appropriate training and oversight in the ethical conduct of research to all undergraduates, graduate students, and postdoctoral researchers who will be supported by NSF to conduct research. The plan must be available for review upon request and to ensure compliance, NSF includes, as a term and condition of its awards, that institutions are responsible for verifying that undergraduate students, graduate students, and postdoctoral researchers supported by NSF to conduct research have received training in the responsible and ethical conduct of research. NSF's implementation of the Responsible Conduct of Research (RCR) requirement recognizes the breadth of research disciplines the Foundation funds, as well as the diversity of the educational levels of the individual researchers the agency supports, to ensure that the training will be effective and appropriately tailored. Specific training needs may vary depending on specific circumstances of research or the specific needs of students intending to pursue careers in basic or applied science after completing their education. Accordingly, it is the responsibility of each institution to determine both the content and the delivery method for the training that will meet the institution's specific needs. Furthermore, each institution must decide if development of content or pedagogical method is required, or if appropriate content and training can be provided from some existing sources or capabilities, and take appropriate action to implement their decisions.

The National Academy of Sciences released a report on Fostering Integrity Research in the spring of 2017 that was supported by the Office of Inspector General of the National Science Foundation under Contract No. NSFCACS11P1173. The OIG Review of Institutions' Implementation of NSF's Responsible Conduct of Research Requirements was issued by the Office of Inspector General of the National Science Foundation. Both of these reports were discussed at the National Science Board in August 2017. NSF then issued an Important Notice No. 140 to Presidents of Universities and Colleges and Heads of Other National Science Foundation Grantee Organizations addressing Training in Responsible Conduct of Research – A Reminder of the NSF Requirement in August 2017. NSF and the NSB are committed to providing appropriate guidance to grantees and to ensuring the sharing of best practices in the responsible conduct of research.

NSF has been and continues to be actively engaged in enhancing the awareness of ethical conduct of research issues by NSF staff, as well as the U.S. and international scientific research and education communities by supporting the development of tools and resources to enhance the ability of research institutions to cultivate cultures of academic and research integrity. NSF's programmatic approach is a broad proactive measure that includes all Directorates in the funding of fundamental research that informs the scientific community and public about best practices in responsible conduct of research. Most notably, the Online Ethics Center (OEC) provides resources, including an Ethics Education Library that institutions can use to deliver effective training that is tailored to meet the needs of their research projects. NSF's cross-directorate program in which all NSF Directorates actively participate, Cultivating Cultures for Ethical STEM (CCE STEM), invests in innovative approaches to enhance research into ethical conduct of research issues that can build the capacity of institutions to develop appropriate ethical conduct of research plans as required by the America COMPETES Act. NSF is actively engaged in heightening the U.S. and international STEM community's awareness of these resources.

Challenge

Provide more oversight on institutional implementation of Responsible Conduct of Research (RCR) requirements and provide meaningful guidance regarding RCR training.

Progress Made in FY 2017

- Issued an Important Notice No. 140 to Presidents of Universities and Colleges and Heads of Other National Science Foundation Grantee Organizations addressing Training in Responsible Conduct of Research – A Reminder of the NSF Requirement in August 2017.
- Continued to support research that provides answers to questions about creating responsible research communities.
- Funded 28 awards in three Directorates under the Robust and Reliable Science Dear Colleague Letters.
- Continued to share state of the art understanding of what approaches are most effective in outreach opportunities with NSF staff and the U.S. and international scientific research and education communities.
- Continued funding of the Online Ethics Center (OEC) website. OEC provides online resources to engineers, scientists, faculty, students and the public to understand and address ethically significant issues that arise in scientific and engineering practice and from new developments in science and engineering.
- Hosted a CCE STEM Principal Investigators' Meeting for researchers working on ethics and the responsible conduct of research (September 2016).
- Funded the workshop on "Qualitative Research Ethics in the Big-Data Era" in Arlington, VA (December 2016) held by Pennsylvania State University. The goal of the workshop was to contribute to improved understanding of issues arising from ethical management of big qualitative datasets in academia and in other national and international institutions that finance and conduct qualitative research. A special issue is being planned and developed to be published in 2018 in *American Behavioral Scientist.* The focus of the special issue is to advance a set of recommendations and guidelines for accountable and ethical management of qualitative data.
- Funded the workshop on "Positive Research Integrity" at the University of Notre Dame, IN (March 2017). The goal of the workshop was to assemble researchers and practitioners of positive ethics, research integrity, philosophy, moral psychology, and character education to discuss how research integrity is perceived as both a research and educational area. A workshop summary and white paper will be produced and disseminated.
- Funded the workshop on "Enhancing robustness and generalizability in the social and behavioral sciences" in Arlington, VA (March 2017) held by Northwestern University. The goal of this workshop was to develop some tools and guidelines to help researchers overcome barriers to broader sampling, and to incentivize doing so through better institutional support. A Sackler Colloquium entitled, "Pressing questions in the study of psychological and behavioral diversity", (September 2017) based upon the workshop will have its papers published in the Proceedings of the National Academy of Sciences.
- Funded an ADVANCE Partnership project designed to transform teaching of research ethics of current and future geoscientists by addressing sexual harassment as scientific misconduct.
- Funded a proposal, "RCN-UBE Incubator: Consortium for the Integration of Ethical Research Practices into Course-based Undergraduate Research Experiences in the Biological Sciences", at the University of Texas at El Paso to explore ethics and responsible conduct of research within the biological sciences.
- Funded an EAGER proposal on "Ethical and Methodological Challenges in Social Media Research" at Texas State University - San Marcos to explore the ethical and methodological challenges of conducting human subjects research when recruitment is solicited through social media accounts.
- Participated in Responsible Conduct of Research outreach (SBE leadership) at Howard University (July 2017).
- Continued monitoring and oversight of CCE-STEM program activities, which included responsible

conduct of research in STEM funding of one workshop at the University of California-Riverside; two institutional transformation grants, one at Virginia Polytechnic Institute and State University and the second at Indiana University; and four standard research grants covering scientific research writing; ethical research culture with community engagement; evaluation of RCR training; and different ethical orientations in STEM.

- Initiated NSF practice requiring the agency's Chief Operating Officer to review research misconduct cases as they are identified.

Future Implementation Milestones

- Continue to support and share research that provides answer to questions about creating responsible research communities, robust and reliable science, and best practices for ethical STEM.
- Analyze the outcomes of the three workshops funded in FY 2017, which will include: (1) structured guidance for addressing the well-documented sampling bias that will contribute to broadening the sampling protocols for experimental behavioral science research; (2) a white paper on in critical thinking skills, recognizing ethical issues, navigating difficult situations, and cultivating interpersonal and communication skills for supporting positive research integrity; and (3) a set of recommendations and guidelines for accountable and ethical management of qualitative data.
- Invite an SBE Distinguished Lecturer to NSF to speak on the responsible conduct of research.
- As more research becomes available on best practices and factors influencing and shaping cultures of research integrity, NSF will develop as needed guidance for institutions concerning the range of appropriate training approaches.
- Evaluate themes and common threads of identified misconduct cases, and compile and evaluate grantees' common responses to these cases and needs for additional RCR training.

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. The quarterly progress of the Agency Priority Goals (APGs) and performance goals are reviewed.

Alignment of Human Capital Efforts with Organizational Performance

In order to drive individual and organizational performance, NSF requires that the performance plans of all employees, executives, and the general workforce contain individual goals aligned with the agency's mission and strategic goals. 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.

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 four 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-fourth 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.[1]

In FY 2017, two directorates convened five COVs, covering all or part of eight divisions. A table of the COVs performed in recent years and planned through FY 2019 is provided on the next page. The chapters of the directorates also contain information on these COVs, as well as information on *ad hoc* reports.

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 2017 follows. For more details about how the results of these specific evaluations are being used to shape agency decisions, see the chapter of the sponsoring directorate. Directorate chapters also contain a list of selected high-impact events (workshops, symposia, or other meetings resulting in publications) that inform their decision-making. For more information about program evaluation and collection and management of NSF programmatic data, see the Office of Integrative Activities chapter's section on NSF's Evaluation and Assessment Capability.

[1] www.nsf.gov/od/oia/activities/cov/covs.jsp

External Evaluations Completed in FY 2017

DIR	Name of Evaluation	Evaluator	Link to report
BIO	Evaluation of the NSF DEB and IOS Switch to Preliminary Proposal Review: Final Report	Abt Associates	www.nsf.gov/bio/pubs/reports/ABT_report.jsp
CISE	Toward 21st-Century Cyber-Physical Systems Education	National Academies	www.nap.edu/catalog/23686/a-21st-century-cyber-physical-systems-education
CISE	Information Technology and the U.S. Workforce: Where Are We and Where Do We Go from Here?	National Academies	www.nap.edu/catalog/24649/information-technology-and-the-us-workforce-where-are-we-and
ENG	A New Vision for Center-Based Engineering Research report:	National Academies	www.nap.edu/catalog/24767/a-new-vision-for-center-based-engineering-research
GEO	Assessment of the National Science Foundation's 2015 Geospace Portfolio Review	National Academies	www.nap.edu/catalog/24666/assessment-of-the-national-science-foundations-2015-geospace-portfolio-review
SBE	The Value of Social, Behavioral, and Economic Sciences to National Priorities	National Academies	www.nap.edu/catalog/24790/the-value-of-social-behavioral-and-economic-sciences-to-national-priorities
OPP	Arctic Research Plan: FY 2017-2021	Interagency Arctic Research Policy Committee	www.iarpccollaborations.org/uploads/cms/documents/iarpc_arctic_research_plan_2017-2021.pdf

List of Committees of Visitors Meetings, FY 2014-FY 2018

DIR	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018 (planned)	FY 2019 (projected)
BIO	Molecular and Cellular Biosciences (MCB) Integrative Organismal Systems (IOS) Emerging Frontiers	Environmental Biology (DEB)	Biological Infrastructure	-	MCB IOS	DEB
CISE	-	Computing and Communication Foundations Computer and Network Systems Information and Intelligent Systems	-	-	Advanced Cyberinfrastructure	-
EHR	Human Resource Development: ADVANCE	Research on Learning in Formal and Informal Settings Graduate Education: GK-12/IGERT/SFS Undergraduate Education: ATE Undergraduate Education: Noyce/S-STEM	-	Human Resource Development EHR Core Research Undergraduate Education: TUES, STEP, WIDER, IUSE: EHR	Graduate Education Undergraduate Education: ATE, IUSE: EHR, S-STEM, Noyce	-
ENG	Electrical, Communications and Cyber Systems (ECCS) Emerging Frontiers in Research and Innovation	Chemical, Bioengineering, Environmental and Transport Systems (CBET) Civil, Mechanical and Manufacturing Innovations (CMMI)	Engineering, Education and Centers Industrial Innovation and Partnerships	-	ECCS Emerging Frontiers and Multidisciplinary Activities	CBET CMMI

Performance

DIR	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018 (planned)	FY 2019 (projected)
GEO	Atmospheric and Geospace Sciences (AGS): Geospace Earth Sciences (EAR) Ocean Sciences (OCE): Integrative Programs Section	AGS: NCAR and Facilities Section OCE: Research and Education	AGS: Atmosphere Section (AS) OPP: Antarctic Sciences Section OPP: Arctic Sciences Section	Education and Diversity Programs: GLOBE, IUSE GEOPATHS, GOLD, Polar Special Initiatives EAR	AGS (programs TBD) OCE (programs TBD)	AGS: AS
MPS	-	Astronomy (AST) Materials Research (DMR) Physics (PHY)	Chemistry Mathematical Sciences	-	-	AST DMR PHY
SBE	-	Office of Multidisciplinary Activities Behavioral and Cognitive Sciences	Social and Economic Sciences	-	-	-
OIA and OISE	International Science and Engineering	Experimental Program to Stimulate Competitive Research (EPSCoR)	Major Research Infrastructure	-	International Science and Engineering	EPSCoR

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."[2]

In FY 2017, NSF contracted with Nexight Group to perform the independent verification and validation. Nexight assessed the validity of NSF data and verified the reliability of the methods used to collect, process, maintain, and report that data. Nexight's FY 2017 report concluded:

> Based on the FY 2017 full year V&V review, the Nexight Team was able to verify the reliability of the processes used to generate the performance measure results for eight of NSF's nine annual performance goals. Data collection processes for the remaining goal were yet to be implemented at NSF and therefore could not be fully verified. Although some of the measures have issues that should be addressed in future years, the data collection processes for all measures adhere to the V&V criteria of Complete, Consistent, Accurate, Timely, and Valid, and are sufficient to ensure that the results are usable. The Nexight Team was also able to confirm the reported results for performance measures under the eight goals that reported results.
>
> Overall, the Nexight Team verifies that NSF relies on sound data collection practices, internal controls, and manual checks of system queries to ensure accurate performance reporting. NSF maintains adequate documentation of its processes and data to allow for an effective V&V review. Based on the V&V assessment, the Nexight Team has confidence in the systems, policies, and procedures used by NSF to calculate results for its performance measures. NSF continues to take concerted steps to improve the quality of its systems and data. The Nexight Team 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]

The data and information required to measure progress towards NSF's performance goals fall into three broad categories.

1. NSF automated administrative systems. Performance monitoring can be a valuable secondary function of such systems. Reporting can include 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; or
   - 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.
2. Data requests of external parties. Qualitative or quantitative information is solicited directly from awardees.

[2] 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.
[3] Nexight Group and Energetics Incorporated, *National Science Foundation Performance Measurement Verification and Validation Report, Fiscal Year 2017*. November 2017.

3. 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.

Lower-Priority Program Activities

The President's Budget identifies the lower-priority program activities, where applicable, as required under the GPRA Modernization Act (31 U.S.C. 1115(b)(10)). The public can access the volume 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.

TECHNICAL INFORMATION

FY 2019 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; $6,150,680,000 to remain available until September 30, 2020 of which not to exceed $600,000,000 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, $873,370,000, to remain available until September 30, 2020.

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, $94,650,000, 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; $333,630,000: *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 2019 for maintenance and operation of facilities and for other services to be provided during the next fiscal year.

OFFICE OF INSPECTOR GENERAL

For necessary expenses of the Office of Inspector General as authorized by the Inspector General Act of 1978, $15,350,000, of which $400,000 shall remain available until September 30, 2020.

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.), $4,320,000: *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 2019 NSF BUDGETARY RESOURCES BY ACCOUNT

(Dollars in Millions)

	FY 2017 Actual	FY 2018 Annualized CR	FY 2019 Request	Change Over FY 2018 Annualized CR Amount	Change Over FY 2018 Annualized CR Percent
RESEARCH AND RELATED ACTIVITIES					
Appropriation	$6,033.65	$5,992.67	$6,150.68	$158.01	2.6%
Unobligated Balance Available Start of Year	11.93	33.33		-33.33	
Unobligated Balance Available End of Year	-33.33				
Adjustments to Prior Year Accounts[1]	22.27				
Subtotal, R&RA	6,034.52	6,026.00	6,150.68		
Transfer to/from other funds	-28.00				
Total Budgetary Resources	$6,006.52	$6,026.00	$6,150.68	$124.68	2.1%
EDUCATION AND HUMAN RESOURCES					
Appropriation	$880.00	$874.02	$873.37	-$0.65	-0.1%
Unobligated Balance Available Start of Year	5.37	7.66		-7.66	
Unobligated Balance Available End of Year	-7.66				
Adjustments to Prior Year Accounts[1]	2.61				
Subtotal, EHR	880.32	881.68	873.37		
Transfer to/from other funds	-6.95				
Total Budgetary Resources	$873.37	$881.68	$873.37	-$8.31	-0.9%
MAJOR RESEARCH EQUIPMENT & FACILITIES CONSTRUCTION					
Appropriation	$209.00	$207.58	$94.65	-$112.93	-54.4%
Unobligated Balance Available Start of Year	37.21	31.36		-31.36	
Unobligated Balance Available End of Year	-31.36				
Adjustments to Prior Year Accounts[1]	2.07				
Subtotal, MREFC	216.92	238.94	94.65		
Transfer to/from other funds	5.86				
Total Budgetary Resources	$222.78	$238.94	$94.65	-$144.29	-60.4%
AGENCY OPERATIONS AND AWARD MANAGEMENT					
Appropriation	$330.00	$327.76	$333.63	$5.87	1.8%
Unobligated Balance Available Start of Year	23.71	0.41		-0.41	
Unobligated Balance Available End of Year	-0.41				
Adjustments to Prior Year Accounts[1]	-0.33				
Subtotal, AOAM	352.97	328.17	333.63		
Transfer to/from other funds	29.09				
Total Budgetary Resources	$382.06	$328.17	$333.63	$5.46	1.7%
NATIONAL SCIENCE BOARD					
Appropriation	$4.37	$4.34	$4.32	-$0.02	-0.5%
Unobligated Balance - Expired	-0.10				
Total Budgetary Resources	$4.27	$4.34	$4.32	-$0.02	-0.5%
OFFICE OF INSPECTOR GENERAL					
Appropriation	$15.20	$15.10	$15.35	$0.25	1.7%
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]	-0.09				
Total Budgetary Resources	$15.10	$15.49	$15.35	-$0.14	-0.9%
TOTAL DISCRETIONARY, NATIONAL SCIENCE FOUNDATION	$7,504.10	$7,494.62	$7,472.00	-$22.62	-0.3%

Totals exclude reimbursable amounts.

[1]Adjustments include upward and downward adjustments to prior year obligations in unexpired accounts.

SUMMARY OF FY 2019 NSF BUDGETARY RESOURCES BY ACCOUNT

(Dollars in Millions)

	FY 2017 Actual	FY 2018 Annualized CR	FY 2019 Request	Change Over FY 2018 Annualized CR Amount	Change Over FY 2018 Annualized CR Percent
EDUCATION AND HUMAN RESOURCES, H-1B					
Appropriation, Mandatory (H1-B Non-Immigrant Petitioner Fees)	$141.07	$142.00	$100.00	-$42.00	-29.6%
Unobligated Balance Available Start of Year	74.63	96.86		-96.86	
Sequestration Previously Unavailable	6.80	9.73	8.25	-1.48	
Sequestration Pursuant OMB M-13-06	-9.73	-8.25			
Unobligated Balance Available End of Year	-96.86				
Adjustments to Prior Year Accounts[1]	3.58				
Total Budgetary Resources	$119.49	$240.34	$108.25	-$132.09	-55.0%
DONATIONS					
Mandatory Programs (Special or Trust Fund)	$40.86	$35.00	$35.00	-	-
Unobligated Balance Available Start of Year	23.93	32.62		-32.62	
Unobligated Balance Available End of Year	-32.62				
Adjustments to Prior Year Accounts[1]	9.42				
Total Budgetary Resources	$41.59	$67.62	$35.00	-$32.62	-48.2%
TOTAL, NATIONAL SCIENCE FOUNDATION	$7,665.18	$7,802.58	$7,615.25	-$187.33	-2.4%

Totals exclude reimbursable amounts.

[1]Adjustments include upward and downward adjustments to prior year obligations in unexpired accounts.

NSF FY 2019 Request Funding by Program

(Dollars in Millions)

PROGRAM	FY 2017 Actual	FY 2018 Annualized CR	FY 2019 Request	FY 2019 Request Change Over FY 2017 Actual Amount	FY 2019 Request Change Over FY 2017 Actual Percent
BIOLOGICAL SCIENCES (BIO)					
BIOLOGICAL INFRASTRUCTURE	$130.35	-	$175.14	$44.79	34.4%
EMERGING FRONTIERS	113.80	-	94.20	-19.60	-17.2%
ENVIRONMENTAL BIOLOGY	145.42	-	146.16	0.74	0.5%
INTEGRATIVE ORGANISMAL SYSTEMS	215.63	-	184.97	-30.66	-14.2%
MOLECULAR & CELLULAR BIOSCIENCES	137.02	-	137.69	0.67	0.5%
TOTAL, BIO	**$742.22**	**-**	**$738.16**	**-$4.06**	**-0.5%**
COMPUTER & INFORMATION SCIENCE & ENGINEERING (CISE)					
ADVANCED CYBERINFRASTRUCTURE	$223.36	-	$210.09	-$13.27	-5.9%
COMPUTING & COMMUNICATION FOUNDATIONS	193.57	-	183.03	-10.54	-5.4%
COMPUTER & NETWORK SYSTEMS	231.36	-	217.09	-14.27	-6.2%
INFORMATION & INTELLIGENT SYSTEMS	194.58	-	192.07	-2.51	-1.3%
INFORMATION TECHNOLOGY RESEARCH	93.06	-	123.14	30.08	32.3%
TOTAL, CISE	**$935.93**	**-**	**$925.42**	**-$10.51**	**-1.1%**
ENGINEERING (ENG)					
CHEMICAL, BIOENGINEERING, ENVIRONMENTAL, & TRANSPORT SYSTEMS	$183.54	-	$180.00	-$3.54	-1.9%
CIVIL, MECHANICAL, & MANUFACTURING INNOVATION	221.05	-	216.90	-4.15	-1.9%
ELECTRICAL, COMMUNICATIONS, & CYBER SYSTEMS	113.78	-	111.60	-2.18	-1.9%
INDUSTRIAL INNOVATION & PARTNERSHIPS	250.26	-	248.42	-1.84	-0.7%
[SBIR/STTR]	*[199.05]*	-	*[198.57]*	*[-0.48]*	*[-0.2%]*
ENGINEERING EDUCATION & CENTERS	108.61	-	97.25	-11.36	-10.5%
EMERGING FRONTIERS AND MULTIDISCIPLINARY ACTIVITIES	53.67	-	67.26	13.59	25.3%
TOTAL, ENG	**$930.92**	**-**	**$921.43**	**-$9.49**	**-1.0%**
GEOSCIENCES (GEO)					
ATMOSPHERIC & GEOSPACE SCIENCES	$253.37	-	$239.30	-$14.07	-5.6%
EARTH SCIENCES	179.13	-	169.23	-9.90	-5.5%
INTEGRATIVE & COLLABORATIVE EDUCATION AND RESEARCH	76.38	-	104.95	28.57	37.4%
OCEAN SCIENCES	316.74	-	339.50	22.76	7.2%
TOTAL, GEO	**$825.62**	**-**	**$852.98**	**$27.36**	**3.3%**

NSF FY 2019 Request Funding by Program

(Dollars in Millions)

PROGRAM	FY 2017 Actual	FY 2018 Annualized CR	FY 2019 Request	FY 2019 Request Change Over FY 2017 Actual Amount	FY 2019 Request Change Over FY 2017 Actual Percent
MATHEMATICAL & PHYSICAL SCIENCES (MPS)					
ASTRONOMICAL SCIENCES	$252.05	-	$230.69	-$21.36	-8.5%
CHEMISTRY	246.24	-	230.58	-15.66	-6.4%
MATERIALS RESEARCH	314.31	-	295.05	-19.26	-6.1%
MATHEMATICAL SCIENCES	233.54	-	218.82	-14.72	-6.3%
PHYSICS	281.43	-	266.73	-14.70	-5.2%
MULTIDISCIPLINARY ACTIVITIES	34.86	-	103.45	68.59	196.8%
TOTAL, MPS	**$1,362.43**	**-**	**$1,345.32**	**-$17.11**	**-1.3%**
SOCIAL, BEHAVIORAL & ECONOMIC SCIENCES (SBE)					
BEHAVIORAL AND COGNITIVE SCIENCES	$94.75	-	$84.95	-$9.80	-10.3%
SOCIAL AND ECONOMIC SCIENCES	97.87	-	86.68	-11.19	-11.4%
MULTIDISCIPLINARY ACTIVITIES	27.08	-	23.37	-3.71	-13.7%
NATIONAL CENTER FOR SCIENCE & ENGINEERING STATISTICS	51.19	-	51.19	-	-
TOTAL, SBE	**$270.89**	**-**	**$246.19**	**-$24.70**	**-9.1%**
OFFICE OF INTERNATIONAL SCIENCE AND ENGINEERING (OISE)	**$48.96**	**-**	**$48.50**	**-$0.46**	**-0.9%**
OFFICE OF POLAR PROGRAMS (OPP)					
OFFICE OF POLAR PROGRAMS	$467.85	-	$534.54	$66.69	14.3%
[US Antarctic Logistical Support Activities]	*[69.28]*	*-*	*[71.00]*	*[1.72]*	*[2.5%]*
Total, OPP	**$467.85**	**-**	**$534.54**	**$66.69**	**14.3%**
INTEGRATIVE ACTIVITIES (IA)					
ESTABLISHED PROGRAM TO STIMULATE COMPETITIVE RESEARCH (EPSCoR)	$162.80	-	$160.00	-2.80	-1.7%
INTEGRATIVE ACTIVITIES	257.46	-	376.72	119.26	46.3%
[Major Research Instrumentation (MRI)]	*[76.20]*	*-*	*[75.00]*	*[-1.20]*	*[-1.6%]*
TOTAL, IA	**$420.27**	**-**	**$536.72**	**$116.45**	**27.7%**
UNITED STATES ARCTIC RESEARCH COMMISSION	**$1.43**	**-**	**$1.42**	**-$0.01**	**-0.7%**
TOTAL, RESEARCH AND RELATED ACTIVITIES	**$6,006.51**	**$5,992.67**	**$6,150.68**	**$144.17**	**2.4%**
EDUCATION & HUMAN RESOURCES (EHR)					
GRADUATE EDUCATION	$272.11	-	$258.55	-$13.56	-5.0%
HUMAN RESOURCE DEVELOPMENT	149.50	-	187.19	37.69	25.2%
RESEARCH ON LEARNING IN FORMAL AND INFORMAL SETTINGS	222.62	-	202.98	-19.64	-8.8%
UNDERGRADUATE EDUCATION	229.14	-	224.65	-4.49	-2.0%
TOTAL, EDUCATION & HUMAN RESOURCES	**$873.37**	**$874.02**	**$873.37**	**-**	**-**

NSF FY 2019 Request Funding by Program

(Dollars in Millions)

PROGRAM	FY 2017 Actual	FY 2018 Annualized CR	FY 2019 Request	FY 2019 Request Change Over FY 2017 Actual Amount	FY 2019 Request Change Over FY 2017 Actual Percent
MAJOR RESEARCH EQUIPMENT & FACILITIES CONSTRUCTION	**$222.78**	**$207.58**	**$94.65**	**-$128.13**	**-57.5%**
AGENCY OPERATIONS AND AWARD MANAGEMENT	**$382.06**	**$327.76**	**$333.63**	**-$48.43**	**-12.7%**
OFFICE OF THE INSPECTOR GENERAL	**$15.10**	**$15.10**	**$15.35**	**$0.25**	**1.6%**
NATIONAL SCIENCE BOARD	**$4.27**	**$4.34**	**$4.32**	**$0.05**	**1.2%**
TOTAL, NATIONAL SCIENCE FOUNDATION	**$7,504.10**	**$7,421.47**	**$7,472.00**	**-$32.10**	**-0.4%**

OBJECT CLASSIFICATION
NSF Consolidated Obligations
(Dollars in Millions)

Object Class Code	Standard Title	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request
11.1	Full-time permanent	$166	-	$171
11.3	Other than full-time permanent	12	-	15
11.5	Other personnel compensation	2	-	2
11.8	Special personal service payment	35	-	41
	Total personnel compensation	215	-	229
12.1	Civilian personnel benefits	55	-	57
21.0	Travel and transportation of persons	21	-	22
23.1	Rental payments	32	-	31
23.2	Rental payments to others	2	-	-
23.3	Communications, utilities, and miscellaneous charges	1	-	2
24.0	Printing and reproduction	1	-	1
25.1	Advisory and assistance services	229	-	191
25.2	Other services	25	-	23
25.3	Purchases of goods and services from Government accounts	158	-	144
25.4	Operation and maintenance of facilities	224	-	225
25.5	Research and development contracts	9	-	9
26.0	Supplies and materials	2	-	1
31.0	Equipment	5	-	4
41.0	Grants, subsidies, and contributions	6,686	-	6,676
	Total, Direct obligations [1]	**$7,665**	**-**	**$7,615**

[1] Includes mandatory obligations, but excludes obligations for reimbursable accounts.

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 2017 Actual
DEFENSE	
Air Force	*$9.5*
Navy	*4.1*
Army	*4.1*
Other DoD (DARPA, NSA & Intelligence)	*8.4*
Subtotal, DoD	$26.1
Commerce (Including Census, NOAA, & NIST)	4.2
Energy	8.4
Executive Office of the President	0.7
Health & Human Services	18.0
Homeland Security	3.3
Interior	1.7
NASA	8.6
Transportation	0.6
OTHER (less than $500,000)	2.7
TOTAL REIMBURSEMENTS	**$74.3**

Consistent with applicable legislation and GAO decisions, agreements include reimbursement for costs that are incurred in the management and administration of these awards.

EXPLANATION OF FY 2017 CARRYOVER INTO FY 2018 BY ACCOUNT

The National Science Foundation's (NSF) total unobligated balance of $203.18 million ($73.70 million for Discretionary accounts, including $554,458 for Incoming Interagency Reimbursable Agreements, and $129.48 million for Mandatory accounts) is described below.

DISCRETIONARY

Within the Research and Related Activities (R&RA) account, $33.88 million (including $554,458 in reimbursable funds) was carried over into FY 2018.

Directorate for Geosciences Polar Programs (no-year funding)
- Amount: $4.10 million
- Reason: Recoveries from prior year obligations that were received too late in the fiscal year year to obligate.
- Obligation: Anticipated FY 2018 Quarter 4

Integrative Activities (IA)
- Amount: $770,880
- Reason: Funds to support Proposal Management Efficiencies contracts that were not ready for obligation in FY 2017.
- Obligation: Anticipated FY 2018 Quarter 2

IA for HBCU Excellence in Research Program
- Amount: $10.0 million
- Reason: These carryover funds will be used for awards that were not ready for obligation in FY 2017.
- Obligation: Anticipated FY 2018 Quarter 2

IA for Hispanic Serving Institution Program
- Amount: $15.0 million
- Reason: These carryover funds will be used for awards that were not ready for obligation in FY 2017.
- Obligation: Anticipated FY 2018 Quarter 2

National Coordination Office for Networking and Information Technology Research and Development
- Amount: $749,261
- Reason: Operational funds are needed to continue government procurements and operations.
- Obligation: Anticipated FY 2018 Quarter 2

National Nanotechnology Coordination Office (NNCO)
- Amount: $349,974
- Reason: NNCO's carryover will be used to fund the required Quadrennial Review of the National Nanotechnology Initiative. In addition, funds carried over will be used to cover rent in NNCO's new location.
- Obligation: Anticipated FY 2018 Quarter 2

The remaining R&RA carryover of $2.36 million consists of funds from throughout the Foundation for selected projects that were not ready for obligation in FY 2017.

Within the Education and Human Resources (EHR) account, $7.66 million was carried over into FY 2018.

Excellence Awards in Science and Engineering (EASE)
- Amount: $4.21 million
- Reason: These carryover funds will be used to recognize recipients of the Presidential Awards for Awards for Excellence in Mathematics and Science Teaching and recipients of the Presidential Awards for Excellence in Science, Mathematics and Engineering Mentoring.
- Obligation: Anticipated FY 2018 Quarter 2

The remaining $3.45 million consists of funds from selected projects that were not ready for obligation in FY 2017.

Within the Major Research Equipment and Facilities Construction (MREFC) account, $31.36 million was carried over into FY 2018.

National Ecological Observatory Network (NEON)
- Amount: $11.06 million
- Reason: Ongoing construction and budget contingency funding needed for project completion scheduled for FY 2018. For additional information, please see the NEON section of the MREFC Chapter.
- Obligation: Anticipated FY 2018 Quarter 4

- Amount: $3.15 million
- Reason: Program funds reserved for unknown or unforeseen risks as identified by NSF.
- Obligation: TBD - Funds held in reserve unless required.

Large Synoptic Survey Telescope
- Amount: $13.64 million
- Reason: Budget contingency funding not obligated in FY 2017.
- Obligation: Anticipated FY 2018 Quarter 4

Daniel K. Inouye Solar Telescope
- Amount: $1.70 million
- Reason: Budget contingency funding not obligated in FY 2017.
- Obligation: Anticipated FY 2018 Quarter 4

The remaining $1.81 million is from completed projects and ended tasks, most recently the Ocean Observatories Initiative and Large Hadron Collider. In FY 2018 NSF intends to use a portion of it for enhanced oversight of MREFC projects. For a further description of these activities, see the MREFC chapter.

Within the Agency Operations and Award Management (AOAM) no-year component, $414,302 was carried over into FY 2018.

NSF Headquarters Relocation
- Amount: $414,302
- Reason: Resources reserved for unanticipated expenses related to the new NSF Headquarters.
- Obligation: Anticipated FY 2018 Quarter 2

Within the Office of Inspector General (OIG) two-year account, $392,372 was carried over into FY 2018.

Office of the Inspector General
- Amount: $392,372
- Reason: Funds are expected to be used to procure financial and forensic audit services. 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.
- Obligation: Anticipated FY 2018 Quarter 4

MANDATORY

Within the H-1B no-year account, $96.86 million was carried over into FY 2018.

Innovation Technology Experiences for Students
- Amount: $21.84 million
- Reason: 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.
- Obligation: Anticipated FY 2018 Quarter 4

Scholarships in Science, Technology, Engineering, and Mathematics
- Amount: $75.02 million
- Reason: 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.
- Obligation: Anticipated FY 2018 Quarter 4

Within the Donations account, $32.62 million was carried over into FY 2018. Donations were received from foreign governments, organizations, and individuals to fund various cooperative efforts in science, research, and education.

Distribution of FY 2017 Carryover into FY 2018
Discretionary and Mandatory Accounts
(Dollars in Millions)

Discretionary Accounts	**Amount**
Research and Related Activities[1]	$33.88
Education and Human Resources	7.66
Major Research Equipment and Facilities Construction	31.36
Agency Operations and Award Management	0.41
Office of Inspector General	0.39
Subtotal	**73.70**
Mandatory Accounts	
H-1B Non-Immigrant Petitioner	96.86
Donations (Special or Trust Fund)	32.62
Subtotal	**129.48**
TOTAL	**$203.18**

[1]Total includes carryover from Interagency Reimbursable Agreements.

EXPLANATION OF VARIANCE OF FY 2017 ACTUALS AND FY 2017 ENACTED

(Dollars in Millions)

	FY 2017 Enacted Level	FY 2017 Actuals	FY 2017 Actuals change over FY 2017 Enacted Amount	Percent	Explanation of Variance: FY 2017 Actuals vs. FY 2017 Enacted Appropriation Transfer (Net)	Obligations From Prior Year Appropriations	Recoveries and Other Adjustments	Unobligated Funds Carried Over to FY 2018
Research and Related Activities	$6,033.65	$6,006.51	-$27.14	-0.4%	-$28.00	$28.08	$6.11	-$33.33
Education and Human Resources	880.00	873.37	-6.63	-0.8%	-6.95	4.83	3.15	-7.66
Major Research Equipment and Facilities Construction	209.00	222.78	13.78	6.6%	5.86	20.00	19.28	-31.36
Award Management and Agency Operations	330.00	382.06	52.06	15.8%	29.09	23.71	-$0.33	-0.41
Office of Inspector General	15.20	15.10	-0.10	-0.7%	-	0.40	-0.11	-0.39
National Science Board	4.37	4.27	-0.10	-2.3%	-	-	-0.10	-
Total, National Science Foundation	**$7,472.22**	**$7,504.10**	**$31.87**	**0.4%**	**-**	**$77.02**	**$28.00**	**-$73.15**

Total excludes reimbursable obligations

In the FY 2019 NSF Budget Request, the amounts shown in the column labeled FY 2017 Actuals represent the actual obligations that occurred in FY 2017. These amounts include the obligation of prior year appropriations and other adjustments, and are therefore different from the FY 2017 Enacted Level. The sources of the variation are:

- Transfer of funds across appropriation accounts.
- Obligations (of carryover) from prior year appropriations.
- Recoveries and other adjustments.
- Unobligated funds carried over from the previous year.

Most activities in the R&RA and EHR accounts have two-year funding, so the carry over and the recoveries are associated with the FY 2016 appropriation. Funding for Polar Programs, Robert Noyce Teacher Scholarship Program, and Major Research Equipment and Facilities Construction activities have no-year funding, so additional obligations in FY 2017 could also be associated with earlier years.

IT RESOURCE STATEMENTS

I affirm that I have reviewed and had significant input in approving IT Investments included in this budget request.

Signed: _____
Dorothy Aronson
Chief Information Officer
National Science Foundation

We jointly affirm that the Chief Information Officer (CIO) had a significant role in reviewing planned IT support for major programs and significant increases and decreases in IT resources reflected in this budget request.

Signed: _____
Teresa Grancorvitz
Acting Chief Financial Officer
National Science Foundation

Signed: _____
Dorothy Aronson
Chief Information Officer
National Science Foundation

The CIO's common baseline rating for Element D ("D1. CIO reviews and approves major IT Investment portion of budget request") is: 3) Fully Implemented – Agency has developed and implemented its plan to ensure that all common baseline FITARA responsibilities are in place.

Signed: _____
Dorothy Aronson
Chief Information Officer
National Science Foundation

I affirm that I have reviewed and certified the use of incremental development practices, as appropriate, for the agency's IT investments.

Signed: _____
Dorothy Aronson
Chief Information Officer
National Science Foundation

QUANTITATIVE DATA TABLE

NATIONAL SCIENCE FOUNDATION
Research and Development Special Analysis
(Dollars in Millions)

	FY 2017 Actual	FY 2018 Annualized CR	FY 2019 Request
Investment Activities			
Conduct of Research and Development			
Basic Research	$4,739.05	-	$4,918.45
Applied Research	778.57	-	761.91
Subtotal, Conduct of R&D	5,517.62	-	5,680.36
Physical Assets			
Research and Development Facilities	240.36	-	210.36
Research and Development Major Equipment	187.69	-	230.63
Subtotal, R&D Facilities & Major Equipment	428.05	-	440.99
Total, Research and Development	5,945.67	-	6,121.35
Conduct of Education and Training	734.34	-	686.99
Non-Investment Activities	824.09	-	663.66
TOTAL	$7,504.10	$7,421.47	$7,472.00

QUANTITATIVE DATA TABLE

RESEARCH AND RELATED ACTIVITIES
Research and Development Special Analysis
(Dollars in Millions)

	FY 2017 Actual	FY 2018 Annualized CR	FY 2019 Request
Investment Activities			
Conduct of Research and Development			
Basic Research	$4,608.57	-	$4,787.45
Applied Research	499.32	-	482.91
Subtotal, Conduct of R&D	5,107.89	-	5,270.36
Physical Assets			
Research and Development Facilities	17.58	-	115.71
Research and Development Major Equipment	187.60	-	230.63
Subtotal, R&D Facilities & Major Equipment	205.18	-	346.34
Total, Research and Development	5,313.07	-	5,616.70
Conduct of Education and Training	310.00	-	262.99
Non-Investment Activities	383.44	-	270.99
TOTAL	$6,006.51	$5,992.67	$6,150.68

QUANTITATIVE DATA TABLE

EDUCATION AND HUMAN RESOURCES
Research and Development Special Analysis

(Dollars in Millions)

	FY 2017 Actual	FY 2018 Annualized CR	FY 2019 Request
Investment Activities			
Conduct of Research and Development			
Basic Research	$130.48	-	$131.00
Applied Research	279.25	-	279.00
Subtotal, Conduct of R&D	409.73	-	410.00
Physical Assets			
Research and Development Facilities	-	-	-
Research and Development Major Equipment	0.09	-	-
Subtotal, R&D Facilities & Major Equipment	0.09	-	-
Total, Research and Development	409.82	-	410.00
Conduct of Education and Training	424.34	-	424.00
Non-Investment Activities	39.21	-	39.37
TOTAL	$873.37	$874.02	$873.37

QUANTITATIVE DATA TABLE

MAJOR RESEARCH EQUIPMENT AND FACILITIES CONSTRUCTION
Research and Development Special Analysis
(Dollars in Millions)

	FY 2017 Actual	FY 2018 Annualized CR	FY 2019 Request
Investment Activities			
Conduct of Research and Development			
Basic Research	-	-	-
Applied Research	-	-	-
Subtotal, Conduct of R&D	-	-	-
Physical Assets			
Research and Development Facilities	$222.78	-	$94.65
Research and Development Major Equipment	-	-	-
Subtotal, R&D Facilities & Major Equipment	222.78	-	94.65
Total, Research and Development	222.78	-	94.65
Conduct of Education and Training	-	-	-
Non-Investment Activities	-	-	-
TOTAL	$222.78	$207.58	$94.65

QUANTITATIVE DATA TABLE

AGENCY OPERATIONS AND AWARD MANAGEMENT
Research and Development Special Analysis
(Dollars in Millions)

	FY 2017 Actual	FY 2018 Annualized CR	FY 2019 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, R&D Facilities & Major Equipment	-	-	-
Total, Research and Development	-	-	-
Conduct of Education and Training	-	-	-
Non-Investment Activities	$382.06	-	$333.63
TOTAL	$382.06	$327.76	$333.63

QUANTITATIVE DATA TABLE

OFFICE OF INSPECTOR GENERAL
Research and Development Special Analysis
(Dollars in Millions)

	FY 2017 Actual	FY 2018 Annualized CR	FY 2019 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, R&D Facilities & Major Equipment	-	-	-
Total, Research and Development	-	-	-
Conduct of Education and Training	-	-	-
Non-Investment Activities	$15.10	-	$15.35
TOTAL	$15.10	$15.10	$15.35

QUANTITATIVE DATA TABLE

NATIONAL SCIENCE BOARD
Research and Development Special Analysis
(Dollars in Millions)

	FY 2017 Actual	FY 2018 Annualized CR	FY 2019 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, R&D Facilities & Major Equipment	-	-	-
Total, Research and Development	-	-	-
Conduct of Education and Training	-	-	-
Non-Investment Activities	$4.27	-	$4.32
TOTAL	$4.27	$4.34	$4.32