MAJOR MULTI-USER RESEARCH FACILITIES

Major Multi-user Research Facilities Funding

(Dollars in Millions)

	FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request	Change Over FY 2012 Enacted Amount	Change Over FY 2012 Enacted Percent
Total Research and Related Activities	**$915.41**	**$896.05**	**$988.07**	**$92.02**	**10.3%**
Operations and Maintenance of Existing Facilities	679.41	657.90	702.86	44.96	6.8%
Federally Funded Research and Development Centers	201.00	195.85	201.91	6.06	3.1%
Operations and Maintenance of Facilities under Construction	28.80	28.80	75.80	47.00	163.2%
R&RA Planning and Concept Development	6.20	13.50	7.50	-6.00	-44.4%
Major Research Equipment and Facilities Construction	**$198.08**	**$197.06**	**$210.12**	**$13.07**	**6.6%**
Total, Major Multi-User Research Facilities	**$1,113.50**	**$1,093.11**	**$1,198.19**	**$105.09**	**9.6%**

Totals may not add due to rounding.

NSF investments provide state-of-the-art tools for research and education, such as multi-user research facilities, distributed instrumentation networks and arrays, accelerators, telescopes, research vessels, aircraft, and earthquake simulators. In addition, investments in internet-based and distributed user facilities are increasing as a result of rapid advances in computer, information, and communication technologies. NSF's investments are coordinated with those of other organizations, agencies, and countries to ensure complementarity and integration. Planning, operations, and maintenance of multi-user facilities are funded through the Research and Related Activities (R&RA) account, and most major construction projects are funded through the Major Research Equipment and Facilities Construction (MREFC) account.

This chapter provides descriptions of each major multi-user research facility supported through the R&RA account and provides funding information by life cycle phase for each facility. The information presented for each facility follows the overall framework established by NSF for large facility projects. Information on projects under construction funded through NSF's MREFC account is provided in the MREFC chapter.

Major Multi-user Research Facilities Funding

(Dollars in Millions)

	FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request	Change over FY 2012 Enacted Amount	Change over FY 2012 Enacted Percent
Operations and Maintenance of Existing Facilities	**$679.41**	**$657.90**	**$702.86**	**$44.96**	**6.8%**
Engineering					
National Nanotechnology Infrastructure Network (NNIN)	16.00	15.86	15.46	-0.40	-2.5%
Network for Earthquake Engineering Simulation	20.39	20.50	22.00	1.50	7.3%
Geosciences					
Academic Research Fleet[1]	92.96	76.75	85.00	8.25	10.7%
Geodetic Facilities for Advancement of Geoscience & EarthScope (GAGE)	11.92	13.18	12.70	-0.48	-3.6%
International Ocean Discovery Program	51.68	44.40	50.00	5.60	12.6%
Polar Facilities and Logistics	294.63	295.79	314.21	18.42	6.2%
Seismological Facilities for Advancement of Geoscience & EarthScope (SAGE)	26.12	26.76	25.70	-1.06	-4.0%
Mathematical and Physical Sciences					
Arecibo Observatory	9.25	8.70	8.00	-0.70	-8.0%
Cornell High Energy Synchrotron Source (CHESS)	19.67	19.67	20.00	0.33	1.7%
Gemini Observatory	21.57	22.07	19.59	-2.48	-11.2%
IceCube	6.90	6.90	6.90	-	-
Large Hadron Collider	18.00	18.00	18.00	-	-
Laser Interferometer Gravitational Wave Observatory	30.40	30.40	39.50	9.10	29.9%
National High Magnetic Field Laboratory	26.80	25.80	32.64	6.84	26.5%
National Solar Observatory	9.10	9.10	8.00	-1.10	-12.1%
National Superconducting Cyclotron Laboratory	21.50	21.50	22.50	1.00	4.7%
Other Facilities[2]	2.52	2.52	2.66	0.14	5.6%
Federally Funded Research and Development Centers[3]	**$201.00**	**$195.85**	**$201.91**	**$6.06**	**3.1%**
National Center for Atmospheric Research	103.00	98.60	99.00	0.40	0.4%
National Optical Astronomy Observatory	26.25	25.50	25.50	-	-
National Radio Astronomy Observatory[4]	71.75	71.75	77.41	5.66	7.9%
Operations and Maintenance of Facilities under Construction	**$28.80**	**$28.80**	**$75.80**	**$47.00**	**163.2%**
Advanced Technology Solar Telescope (ATST)	2.00	2.00	2.00	-	-
National Ecological Observatory Network (NEON)	-	-	21.00	21.00	N/A
Ocean Observatories Initiative (OOI)	26.80	26.80	52.80	26.00	97.0%
R&RA Planning and Concept Development	**$6.20**	**$13.50**	**$7.50**	**-$6.00**	**-44.4%**
Pre-construction Planning[5]	-	2.00	1.00	-1.00	-50.0%
Concept and Development for MREFC projects	6.20	11.50	6.50	-5.00	-43.5%
Major Research Equipment and Facilities Construction	**$198.08**	**$197.06**	**$210.12**	**$13.07**	**6.6%**
Total, Major Multi-User Research Facilities	**$1,113.50**	**$1,093.11**	**$1,198.19**	**$105.09**	**9.6%**

Totals may not add due to rounding.

[1] An additional $2.0 million in FY 2012 Enacted and $1.0 million in FY 2013 for Regional Class Research Vessels is included in pre-construction planning.

[2] Other Facilities includes support for other physics and materials research facilities.

[3] Federally Funded R&D Centers does not include support for the Science and Technology Policy Institute, which is an FFRDC but not a multi-user research facility.

[4] Operations and maintenance of ALMA are included in NRAO.

[5] Pre-construction planning includes R&RA funding for potential next-generation major multi-user facilities.

NSF's Facilities Investments in FY 2014

The following pages contain information on NSF's ongoing facilities in FY 2014.

Facilities

Federally Funded R&D Centers

Other Facilities Funding

ACADEMIC RESEARCH FLEET

$86,000,000
+$7,250,000 / 9.2%

Academic Research Fleet
(Dollars in Millions)

FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request	Change over FY 2012 Enacted Amount	Percent
$92.96	$78.75	$86.00	$7.25	9.2%

The Academic Research Fleet consists of 19 vessels in the University-National Oceanographic Laboratory System (UNOLS). These vessels range in size, endurance, and capabilities, enabling NSF and other federally-funded scientists with the means to conduct ocean science research with a diverse fleet capable of operating in coastal and open ocean waters. Funding for the Academic Research Fleet includes investments in ship operations; shipboard scientific support equipment; oceanographic instrumentation and technical services; and submersible support. Funding levels reported here reflect investments in the Directorate of Geosciences (GEO) by the Division of Ocean Sciences (OCE). In addition to operations, OCE has undertaken selected construction projects based on inter-agency planning and coordination as discussed in the Federal Oceanographic Fleet Status Report published in 2007.

Total Obligations for the Academic Research Fleet
(Dollars in Millions)

	FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013	FY 2014 Request	ESTIMATES[1] FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Operations and Maintenance	$87.89	$76.75	$85.00	$85.00	$85.00	$85.00	$85.00	$85.00
Fleet Renewal								
Human Occupied Vehicle	5.08	-	-	-	-	-	-	-
Regional Class Research Vessel	-	2.00	1.00	2.00	-	-	-	-
Total, Academic Research Fleet	**$92.96**	**$78.75**	**$86.00**	**$87.00**	**$85.00**	**$85.00**	**$85.00**	**$85.00**

Totals may not add due to rounding.

[1] Outyear funding estimates are for planning purposes only.

The Academic Research Fleet serves as the main platform for the collection of data and testing of hypotheses about the structure and dynamics of the ocean. Scientists contribute to advances in many areas including climate variability, marine ecosystems, fisheries, and ocean-related natural hazards, such as tsunamis through use of these facilities. Participating graduate and undergraduate students interact with scientists and marine technicians, enabling them to gain first-hand exposure to ocean science field research. Increasingly, technological innovations allow research conducted at sea to be transmitted via satellite back to the classroom, broadening the educational impact of the vessels.

The Academic Research Fleet is supported through an interagency partnership, principally with the Office of Naval Research (ONR) and the National Oceanic and Atmospheric Administration (NOAA). The operating costs for the Fleet are divided proportionally among the vessel users based on usage; NSF supports approximately 65 percent of the total. NSF also coordinates with ship-operating and ship-user academic institutions through UNOLS.

Support for scientists using the Fleet is provided by both NSF and other federal and state agencies. Within NSF, science is funded through competitive peer-reviewed proposals, most typically funded within OCE and through selected programs in the Division of Earth Sciences (EAR), the Division of Atmospheric and Geospace Sciences (AGS), the Division of Polar Programs (PLR), and the Directorate for Biological Sciences (BIO). Approximately 25 percent of OCE proposals request ship time. Not reflected in this number is the science that utilizes samples or data collected on prior cruises, scientists piggy-backing on scheduled cruises to accomplish additional science, international scientists sailing with the U.S. Academic Research Fleet, and science funded by other agencies.

The slight reduction in ship operation and upgrade costs is the result of reduced ship demand and the completion of support for upgrading the Human Occupied Vehicle *ALVIN*. The FY 2014 Request of $85.0 million will support approximately 2,100 ship operating days.

Fleet Operations

- 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. In addition, NSF oversees the Fleet through site visits, ship inspections, and participation at UNOLS Council and Committee meetings by NSF program directors. Several program directors within OCE at NSF, at NOAA, and at ONR are involved in the activities and overall oversight of the Academic Research Fleet. NSF conducted a Business Systems Review (BSR) of Columbia University/Lamont Doherty Earth Observatory as the operator of the R/V *LANGSETH*, and issued a final report in September 2010. No BSRs of Academic Research Fleet operating institutions are currently scheduled for 2013 or 2014.
- Management: Management of an operating institution's ship-operating facilities varies with the scale of the operation, but the core responsibility typically resides with the Director of the Institution, the Marine Superintendent (for all aspects of the facility), and the Ship's Captain (for at-sea operations). For larger multi-ship-operating institutions, a Chief of Marine Technicians, schedulers, and finance administrators may also be involved in facility management.
- Reviews: Based on projected science requirements identified in recent reports and workshops, a fleet of vessels supporting ocean science research will be needed far into the future. Recent documents supporting this need include the *National Ocean Policy* and the *Final Recommendations of the Interagency Ocean Policy Task Force* of July 19, 2010. Two applicable reports by the National Research Council (NRC) include *Science at Sea: Meeting Future Oceanographic Goals with a Robust Academic Research Fleet* published in 2009, and *Critical Infrastructure for Ocean Research and Societal Needs in 2030* published in 2011. In coordination with UNOLS and the other federal agencies which invest in ocean research, the Interagency Working Group on Facilities (IWG-F), which has been renamed as the Interagency Working Group on Facilities and Infrastructure (IWG-FI) under the National Ocean Policy, published a *Federal Oceanographic Fleet Status Report* in December 2007 reviewing the status and describing plans for modernizing the federal and academic oceanographic research and survey fleet. Ship operations and technical services proposals undergo external review by peers every five years. Detailed annual reports describing activities accomplished are provided by the operating institutions and budgets are negotiated yearly since they are dependent on the number of days the ships will be at sea in support of NSF-funded research programs.

Fleet Modernization

- Oversight: The NSF coordinator for Fleet modernization activities is the Program Director for Ship Acquisition and Upgrades, within the Integrative Programs Section (IPS) in OCE, with additional IPS staff providing project management assistance as required.
- Regional Class Research Vessel (RCRV): In March 2012, NSF leadership approved the request to

advance the RCRV to the Conceptual Design Review (CDR) phase as a candidate Major Research Equipment and Facilities Construction (MREFC) project. A solicitation was released in April 2012 to select the lead institution for the design and construction of up to three vessels. Competitive proposals were received in September 2012 and a panel of experts convened in early November 2012 to provide recommendations to NSF. On February 1, 2013, NSF made an award to Oregon State University for advancement to CDR. Funds for CDR will be provided from the Research and Related Activities account. Management and oversight will be similar to the R/V *SIKULIAQ* project. NSF has held several discussions with the NOAA Office of Marine and Aviation Operations to explore the potential for collaboration between the two agencies on the design of the RCRV and the modernization efforts being considered for the NOAA mid-size vessels. In addition, NSF is an active participant in the IWG-FI Ship Subcommittee, which is developing an update to the 2007 *Federal Oceanographic Fleet Status Report*, an action in the draft *National Ocean Policy (NOP) Implementation Strategy*[1]. The role of the RCRV in meeting the needs across the government agencies for research vessels in support of ocean science research is an integral aspect of the Fleet Status Report Update. Decisions on proceeding to further development stages will be based upon NSF, National Science Board (NSB), and interagency reviews.

Other Ongoing Activities

- Major overhaul and upgrade to the submersible Human Occupied Vehicle *(HOV) ALVIN* will be completed in FY 2013. This project, begun in FY 2004, to design and build an all-new submersible, experienced significant cost over-runs in 2008 due to schedule delays, increases in labor costs and levels of effort, and a rise in titanium prices. As a result, the project was re-scoped to be a major overhaul and upgrade of the existing vehicle and was renamed to the *ALVIN* Upgrade Project. It was placed on a revised review path, which included a Preliminary Design Review (PDR) in December 2009 and a Final Design Review (FDR) in September 2010. The FDR Panel recommended the project continue and determined the budget was adequately defined. The Panel also recommended NSF partner with the Navy, specifically Naval Sea Systems Command (NAVSEA), to achieve a reinstatement of certification to ensure the operational capability and safety of *ALVIN*. NSF subsequently entered into an interagency agreement with NAVSEA to do so, and the Woods Hole Oceanographic Institution (WHOI) team is supporting this effort.

  The *ALVIN* Upgrade Project is scoped in two phases. Phase I is the integration of a new titanium 6,500-meter-capable personnel sphere with existing *ALVIN* vehicle components. Phase I completion will provide a depth capability of 4,500 meters, the limit of the current *ALVIN* components to be retained during Phase I. A potential Phase II would provide upgrades to permit operations to a depth of 6,500 meters, but there has been no implicit or explicit commitment to proceed with Phase II at this time. Certification and sea trials for operation of the Phase I vehicle are scheduled for spring 2013, with an anticipated return to standard science operations in summer 2013.

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. Awardees are subject to additional oversight measures, including BSRs conducted by NSF. In FY 2012, NSF announced plans for the FY 2013 retirement of the *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. This retirement action was completed on March 8, 2013.

[1] www.whitehouse.gov/administration/eop/oceans/implementationplan

R/V *SIKULIAQ*, formerly the Alaska Region Research Vessel (ARRV):

The Research Vessel *SIKULIAQ* (formerly known as the Alaska Region Research Vessel - ARRV) represents NSF's first major contribution to Fleet renewal in over twenty years. Construction of the *SIKULIAQ* was funded through the MREFC account, partially with American Recovery and Reinvestment Act (ARRA) funds. The project is led by the University of Alaska, Fairbanks (UAF) with engineering support from design through construction provided by UAF's naval architect, The Glosten Associates, Inc. Shipyard construction began in early 2011 and the vessel was successfully launched in October 2012. Delivery of the *SIKULIAQ* to UAF is scheduled for July 2013. This will be followed by a period of final outfitting, science trials, and transit to the first science operational area. Science operations are projected to begin in early 2014 with transition to the OCE Ship Operations Program for funding support. Ice trials and a warranty shipyard inspection will be conducted in 2014 using MREFC funds; both of which were within the original project scope.

The increased capabilities of the *SIKULIAQ* are expected to dramatically increase the number of proposals addressed to NSF for Arctic science. UAF conducted two science planning workshops (May 2011 and February 2012), to alert the U.S. science community to the vessel's capabilities and availability to support science beginning in 2014. Individual projects vary greatly in cost, as do the number of projects supported onboard at any given time. Assuming two simultaneous projects onboard for 3-4 weeks at a time and the average grant size in the Division of Ocean Sciences (OCE) in the Directorate for Geosciences (GEO), over $17.0 million in research conducted from R/V *SIKULIAQ* would be supported annually.

Baseline History

Total Obligations for R/V *SIKULIAQ (ARRV)*

(Dollars in Millions)

	Prior Years[1]	FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request	ESTIMATES FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
R&RA Obligations:									
Concept & Development	$2.24	-	-	-	-	-	-	-	-
Management & Operations	-	-	-	4.17	8.34	8.50	8.50	8.50	8.50
Subtotal, R&RA Obligations	$2.24	-	-	$4.17	$8.34	$8.50	$8.50	$8.50	$8.50
MREFC Obligations:									
Implementation	51.42		-		-	-	-	-	-
ARRA	148.07		-		-	-	-	-	-
Subtotal, MREFC Obligations	$199.49	-	-	-	-	-	-	-	-
Total, *SIKULIAQ*	**$201.73**	**-**	**-**	**$4.17**	**$8.34**	**$8.50**	**$8.50**	**$8.50**	**$8.50**

Totals may not add due to rounding.

[1] Concept & Development funding and Implementation funding are cumulative of all prior years; Management & Operations funding reflects the FY 2011 Actual only.

Satellite observations have shown that the perennial ice in the Arctic is thinning at a rate of nine percent per decade, which is beginning to have major regional and global consequences. Research is urgently needed on topics ranging from climate change, ocean circulation, ecosystem studies, and fisheries research, to natural hazards and cultural anthropology. The *SIKULIAQ* will provide a sophisticated and significantly larger platform for scientists, as well as graduate and undergraduate students to participate in complex multidisciplinary research activities and will enable the training of the next generation of scientists with the latest equipment and technology. The *SIKULIAQ* is expected to greatly expand research capabilities in the Arctic with up to 270-300 science days at sea annually. The ice-strengthened

hull will allow the vessel to operate in seasonal ice up to one meter thick and an anti-roll tank will permit it to operate effectively in the open waters of the Bering Sea, Gulf of Alaska, and North Atlantic. Due to its size and projected operating area, the *SIKULIAQ* will operate as a Global Class vessel within the U.S. Academic Research Fleet.

Management and Oversight

- NSF Structure: NSF oversight is described in the Program's Internal Management Plan (IMP). The NSF Program Officer for Ship Acquisition and Upgrades has primary responsibility for oversight of the project and resides within GEO/OCE/IPS. Periodic oversight is provided by a Project Advisory Team (PAT), which includes staff from GEO, the Division of Acquisition and Cooperative Support (DACS), the Large Facilities Office (LFO), the Office of the General Counsel (OGC), and the Office of Legislative Public Affairs (OLPA). External consultants and staff from IPS, LFO, and DACS provide the Program Officer with routine project management and technical assistance. To ensure effective management and oversight, monthly and annual reports provided by the UAF project office are closely monitored by the *SIKULIAQ* Program Officer for deviations from the established baseline using Earned Value Management. NSF conducted a Business Systems Review (BSR) of UAF as the awardee for the design and construction project and as the future operator of R/V *SIKULIAQ*. A final report was issued in July 2011.
- External Structure: UAF maintains project management offices in both Fairbanks and Seward, AK. UAF management also includes an experienced on-site team in Marinette, Wisconsin that will remain at the shipyard until delivery. The *SIKULIAQ* Oversight Committee (SOC), which includes community experts in research vessel design, construction, and operations, convenes monthly to review project status and provide technical and science support advice to both UAF and NSF.
- Reviews: With the ship now launched, NSF will conduct one more annual project review in September 2013, the Trials and Operational Readiness Review.

Cost and Schedule

The total project cost approved by NSF and NSB following FDR is $199.50 million. NSF first requested construction funding for the *SIKULIAQ* through the MREFC account in FY 2007. The project received an initial appropriation of $9.43 million in that year, followed by an additional appropriation of $42.0 million in FY 2008. $148.07 million was provided through ARRA. The majority of this total, $138.0 million, or 70 percent, is the fixed price contract with the shipyard. UAF management, which includes the purchase of propulsion units as Owner-Furnished Equipment, totals $34.70 million (17 percent). Final outfitting, science trials, and delivery are $11.20 million (6 percent). Uncommitted project contingency for the shipyard contract is approximately $8.30 million (4.2 percent).

Risks

Risk mitigation strategies have been employed by UAF, and the risk analyses reviewed by the R/V *SIKULIAQ* Project Review Panel in July 2012 indicate that sufficient contingency is currently in place to handle these remaining project risks. The Panel also was satisfied that proper change and contingency management control processes are in place to facilitate the project completing within budget.

Future Operations Costs

Vessel operations will be governed by the terms of a separate cooperative agreement with UAF through the Ship Operations Program within OCE/IPS. Daily rate estimates for both the ship and technical services will be updated in 2013. It is anticipated that OCE will utilize at least 65 percent of the annual vessel availability based on historical data from other Global Class ships in the Academic Research Fleet. Up to 35 percent of the *SIKULIAQ's* schedule is expected to be available to PLR and to other federal agencies. In short, the *SIKULIAQ* will fold into an already well-established framework for operating the Academic Research Fleet.

ARECIBO OBSERVATORY

$8,000,000
-$700,000 / -8.0%

Arecibo Observatory
(Dollars in Millions)

FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request	Change over FY 2012 Enacted Amount	Change over FY 2012 Enacted Percent
$9.25	$8.70	$8.00	-$0.70	-8.0%

Totals may not add due to rounding.

The Arecibo Observatory (Arecibo), formerly the National Astronomy and Ionosphere Center, is a center for multidisciplinary research and education enabled by world-class observational facilities. The Observatory's principal facility is the world's largest single-dish radio/radar telescope, a 305-meter diameter reflector located near the town of Arecibo in western Puerto Rico on 120 acres of U.S. Government-owned land. Arecibo Observatory is currently operated and managed by SRI International and subawardees USRA (Universities Space Research Association) and Universidad Metropolitana (UMET) under a cooperative agreement with NSF that began October 1, 2011. It serves over 300 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. NSF does not provide awards targeted specifically for use of Arecibo Observatory, although many users are supported through NSF or NASA grants to pursue scientific programs that require use of the facility. Review and proposal-handling procedures have recently been revised to ensure greater accountability of long-term projects.

Including the Angel Ramos Foundation Visitor Center, Arecibo has a staff of about 120 full-time-equivalent positions, of which approximately 90 are supported by NSF funds. A permanent staff of 17 scientists and 34 engineers, technicians, and operators is available to help visiting investigators with observing programs. The remainder includes 26 management, administrative, and clerical positions, 37 maintenance staff, and several postdoctoral scholars and students.

Total Obligations for the Arecibo Observatory
(Dollars in Millions)

	FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request	ESTIMATES[1] FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Operations and Maintenance	$9.25	$8.70	$8.00	$8.00	$8.20	$8.20	$8.20	$8.20
Astronomical Sciences (MPS)	*5.63*	*5.50*	*4.50*	*4.00*	*4.10*	*4.10*	*4.10*	*4.10*
Atmospheric & Geospace Sciences (GEO)	*3.63*	*3.20*	*3.50*	*4.00*	*4.10*	*4.10*	*4.10*	*4.10*
Total, Arecibo	**$9.25**	**$8.70**	**$8.00**	**$8.00**	**$8.20**	**$8.20**	**$8.20**	**$8.20**

Totals may not add due to rounding.

[1] Outyear funding estimates are for planning purposes only. The current cooperative agreement ends on September 30, 2016.

Arecibo is jointly supported by the Division of Astronomical Sciences (AST) in the Directorate for Mathematical and Physical Sciences (MPS) and the Division of Atmospheric and Geospace Sciences

(AGS) in the Directorate for Geosciences (GEO). In 2006 the AST Senior Review recommended a reduction of approximately 20 percent in annual NSF support for Arecibo to roughly $10.0 million by 2010 ($8.0 million from AST plus an assumed value of $2.0 million from AGS). NSF funding for Arecibo in FY 2008–2010 reflected this recommended ramp-down. The AST Senior Review also recommended that sufficient additional financial or in-kind personnel contributions be found to operate Arecibo with competitive scientific productivity after 2011 with an AST contribution not to exceed about half of the overall Arecibo budget. Planned AST support through FY 2016 is based upon the Senior Review recommendations, guidance from a third-party cost review of AST facilities, and a third-party estimate of Arecibo's non-scientific costs. As AST has ramped down support for Arecibo, AGS has significantly increased support, with funding estimated to ramp up to parity with AST in FY 2015 and beyond. (More on AGS activities at Arecibo can be found below under Management and Oversight).

In the latter part of 2011 and the first half of 2012, AST conducted a Portfolio Review in which a diverse 17-member panel of U.S. astronomers evaluated and recommended a balanced AST program for near- to medium-term budget scenarios that now appear more realistic than the scenario assumed by the 2010 National Research Council decadal survey in astronomy and astrophysics. The Portfolio Review Committee recommendations were driven by the desire to retain scientifically important capabilities traceable to that 2010 decadal survey. The recommendation of the Portfolio Review Committee was that support for Arecibo should be continued at funding levels near those currently planned, with a re-evaluation later in this decade. Decisions have not yet been made regarding detailed implementation of the Portfolio Review Committee recommendations.

Partnerships and Other Funding Sources: Arecibo leverages NSF support with funding from other federal and non-federal sources. Since FY 2010, the NASA Near Earth Object Observation Program has committed $2.0 million to Arecibo in support of the planetary radar program. NASA support is expected to continue at this level, subject to availability of appropriated funds. In FY 2010, observatory management finalized an assistance agreement with the Puerto Rico Infrastructure Financing Authority to receive $3.0 million for major infrastructure improvements at Arecibo Observatory. A grant to the Visitor Center from the Puerto Rico Department of Education is being finalized in early 2013.

An aerial image of the Arecibo Radio Telescope in Puerto Rico. The platform suspension structure, including the Gregorian dome that houses the main suite of research instruments, is visible over the 305-meter primary reflector dish below. *Credit: Arecibo Observatory/NSF.*

Education and Public Outreach (EPO): Arecibo hosts a Research Experiences for Undergraduates (REU) site, and Ph.D. students receive training through use of the facility. In collaboration with the National Radio Astronomy Observatory (NRAO), Arecibo holds a summer school on single-dish radio astronomy techniques. Arecibo also sponsors a major outreach program in Puerto Rico via the Angel Ramos Foundation Visitor Center and Learning Center, as well as summer workshops for K-12 teachers. This center attracts roughly 100,000 visitors each year; over 1.3 million people have visited since its opening in 1997. With funds from the Puerto Rico Department of Education, Arecibo recently hosted 25,000 K–12 school children through the *Inspiration for Science* program that provided transportation to the Observatory and science enrichment activities at no cost to participants.

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 observing proposals; the current average oversubscription rate of the telescope is approximately 3.5. This metric accounts for the number of current astronomical surveys requesting time for a given area of sky, plus the time request in the program year for small radio astronomy projects, solar system observations, and atmospheric sciences programs. About 80 percent of astronomy users conduct their observing remotely via networked control software, while radar observations typically employ on-site users.

Management and Oversight

- Division of Astronomical Sciences (AST), $4.50 million: AST funds basic operations costs and science programs in passive radio astronomy and solar system radar astronomy. Funding for the Astronomy program continues to decrease in FY 2013 and FY 2014, in response to recommendations of the AST Senior Review. Operational scope changes are anticipated in response to decreased AST funding, as part of the current five-year award for Arecibo management and operations. Since FY 2010, NASA has provided substantial support for planetary radar astronomy (see above).
- Division of Atmospheric and Geospace Sciences (AGS), $3.50 million: The incoherent scatter radar at Arecibo is part of an NSF-supported network of radars strategically distributed to observe the transport of radiative energy and charged particles, from their origins at the sun to their deposition in Earth's upper atmosphere. The unique sensitivity of the Arecibo incoherent scatter radar system allows it to measure the density, temperature, and motion of plasma in Earth's ionosphere with unrivaled time and spatial resolution. Arecibo is also the only aeronomy observatory located at tropical mid-latitudes, where many important ionospheric processes take place. An ionospheric high-frequency heating facility is currently under construction at Arecibo with completion anticipated in FY 2013.
- NSF Structure: Ongoing oversight is provided by the lead NSF program director in AST, in close cooperation with an assigned program director in AGS and in consultation with community representatives. The program directors make use of detailed annual program plans, long range plans, quarterly technical and financial reports, and annual reports submitted to NSF by SRI, as well as attending SRI governance committee meetings as appropriate. To address issues as they arise, the program directors work closely with other offices at NSF, particularly the Division of Acquisition and Cooperative Support; the Office of General Counsel; and the Large Facilities Office of the Office of Budget, Finance, and Award Management. The AST and AGS program directors conduct periodic site visits and frequent teleconferences.
- External Structure: Management is via a cooperative agreement with SRI and its subawardees, USRA and UMET. The awardees provide management and oversight through their own advisory and visiting committees, including an Arecibo Observatory Users Committee, a Scientific Management Advisory Committee, a Council of Puerto Rican Chancellors and Stakeholders, and an Executive Governing Committee. The Arecibo Director, resident at the telescope site, is the Principal Investigator of the operations award for the facility. Three deputy directors in the areas of Atmospheric Sciences, Planetary Radar, and Puerto Rican EPO report to the Arecibo Director. A new five-year cooperative agreement began in FY 2012.
- Reviews:
  - Last management review was held in March 2007. The next review is planned for early FY 2015.
  - Follow-up assessment of the response to the AST Senior Review recommendations was completed in March 2008.
  - AST and AGS jointly conduct annual external reviews of Arecibo program plans; the most recent review was held in November 2012, and these will continue annually.
  - Business Systems Review (BSR) involving all three partner organizations of Arecibo was conducted in late 2012.

Renewal/Competition/Termination

The current cooperative agreement with SRI for the management of Arecibo was awarded on schedule on October 1, 2011, when SRI succeeded the previous managing organization, Cornell University. This followed a competitive process for a new five-year cooperative agreement, consistent with National Science Board policy. This agreement is in effect through September 30, 2016.

In the context of the transition to a new managing organization, funds previously allocated to Arecibo infrastructure were re-assigned to cover allowable transition costs. Hence, a subsequent proposal was received and an award granted in FY 2012 in the amount of $1.85 million to accomplish these previously planned tasks related to maintaining Arecibo technical infrastructure and safety. These ranged from completing the painting of the azimuth arm, to upgrading electronics for digital Very Long Baseline Interferometry (VLBI) equipment, to demolition and modification of building structures.

CORNELL HIGH ENERGY SYNCHROTRON SOURCE

$20,000,000
+$330,000 / 1.7%

Cornell High Energy Synchrotron Source

(Dollars in Millions)

FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request	Change over FY 2012 Enacted Amount	Percent
$19.67	$19.67	$20.00	$0.33	1.7%

Totals may not add due to rounding.

The Cornell High Energy Synchrotron Source (CHESS) is a high-intensity, high-energy X-ray users facility supported by NSF with partial interagency support from the National Institutes of Health (NIH). It uses synchrotron light given off by charged particles, both electrons and positrons, as they circulate in a ring at nearly the speed of light. CHESS provides capabilities for X-ray research in physics, chemistry, biology, materials, and environmental sciences. Areas of emphasis include soft matter and thin film studies, solution scattering, nanomaterials, high-pressure science, structural biology, time-resolved studies of materials, and X-ray studies of items of art and archaeology. Stewardship and oversight of CHESS is provided through the NSF Division of Materials Research (DMR) within the Directorate for Mathematical and Physical Sciences (MPS).

The FY 2014 Request supports operations of CHESS as a user facility and is consistent with funding levels in previous years. Funding will allow continued operation of the facility in support of synchrotron light users.

Total Obligations for the Cornell High Energy Synchrontron Source

(Dollars in Millions)

	FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request	ESTIMATES[1] FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Operations and Maintenance	$19.67	$19.67	$20.00	$20.00	$20.00	$20.00	$20.00	$20.00

[1] Outyear funding estimates are for planning purposes only. The current cooperative agreement ends in March 2014.

The CHESS user program supports work in cancer research, new materials for electronics, aircraft and biotechnology, batteries, fuel cells, solar cells and other energy applications. X-ray detectors developed at CHESS are now in use at 3rd and 4th Generation X-ray sources around the world, including the world's first hard X-ray laser, the Department of Energy's (DOE) Linear Coherent Light Source.

CHESS staff assists in transferring radio frequency technology based on superconductors to industry. Several CHESS users are from industry, including pharmaceutical corporations (such as Rib-x Pharmaceuticals) and the research arms of Xerox and General Motors. Medical institutions such as the Dana Farber Cancer Institute, Boston Biomedical Research Institute, and Memorial Sloan-Kettering Institute are users of the facility. CHESS also has collaborations with DOE-supported synchrotron facilities such as the Advanced Photon Source and the National Synchrotron Light Source.

CHESS supports and enhances Ph.D. level graduate education, postdoctoral research, and research experiences for undergraduates and for K-12 science teachers. Each year there are about 25 Ph.D. degrees granted as a result of CHESS research. More than 60 undergraduates participate in research at the facility during the academic year; about 16 undergraduates and 10 K-12 teachers participate during the summer. In this educational role, CHESS is a key training ground for X-ray science and accelerator physics with CHESS students and postdoctorates going on to staff other X-ray facilities in the U.S. and around the world.

Management and Oversight

- NSF Structure: CHESS operations are supported by DMR and NIH. CHESS also hosts MacCHESS, a NIH-funded macromolecular crystallography program at Cornell. NSF and NIH provide oversight of CHESS through regular site visits by external reviewers.
- External structure: CHESS is administered by the Cornell Laboratory of Accelerator-based Sciences and Education (CLASSE), which reports to Cornell's Vice-Provost for Research. CHESS is operated by Cornell University in accordance with a cooperative agreement with NSF that set goals and objectives for the facility.
- CHESS is a national user facility accessed on the basis of competitive proposal review. The primary function of the CHESS staff is to maintain and operate the facility and to assist users. A policy and advisory board, appointed by the Cornell Vice President for Research, provides advice to the director of CHESS on policies related to the use and development of CHESS facilities and equipment for user experiments. A users committee appointed by the users of CHESS advises the director on matters of facilities operations and priorities for the users. An annual users meeting and several workshops help disseminate results from the facility.
- Reviews:
  - Annual site visit review of CHESS operations, November 2012.
  - Business Systems Review (BSR), final report issued in September 2011.
  - A subcommittee of the Mathematical and Physical Sciences Advisory Committee (MPS-AC) is conducting a study of NSF's role in synchrotron science, with a report due in Spring 2014. This report will inform the division's long-term future plans for investments in this area.

Renewal/Recompetition/Termination

In December 2009, a four-year award was approved by the National Science Board. The resulting cooperative agreement between NSF and Cornell University funds operations until March 2014. DMR is reviewing a five-year renewal proposal that requests continuing operations starting April 2014.

GEMINI OBSERVATORY

$19,590,000
-$2,480,000 / -11.2%

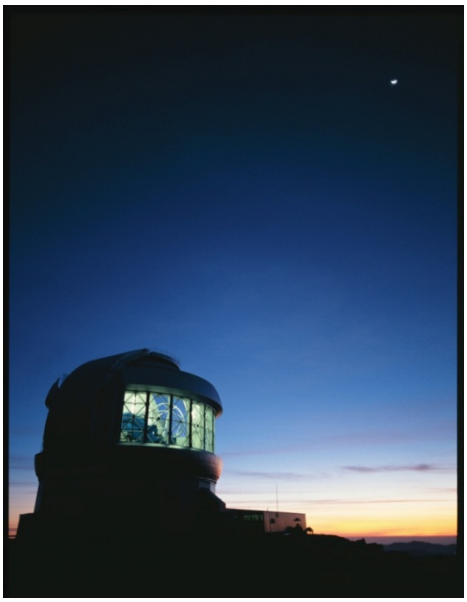
Gemini Observatory
(Dollars in Millions)

FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request	Change over FY 2012 Enacted Amount	Percent
$21.57	$22.07	$19.59	-$2.48	-11.2%

Totals may not add due to rounding.

The Gemini Observatory consists of two optical/infrared 8-meter telescopes, one each in the northern and southern hemispheres. The northern telescope, Gemini North, is situated on Mauna Kea, Hawaii at an altitude of 4,200 meters, while Gemini South is located on Cerro Pachón, Chile, at an altitude of 2,700 meters. This siting of the two telescopes assures complete coverage of the sky and complements the observations from space-based observatories. The Gemini telescopes provide views of the center of our own Galaxy as well as the Magellanic Clouds, our nearest galactic neighbors. Both telescopes are designed to produce superb image quality and both use sophisticated adaptive optics technology to compensate for the blurring effects of the Earth's atmosphere.

Astronomers are working to resolve important questions about the age and rate of expansion of the universe, its overall topology, the amount and nature of non-luminous matter, the epoch of galaxy formation, the evolution of galaxies (including our own) once they are formed, and the formation of stars and planetary systems. The current generation of optical/infrared telescopes with large aperture (8-meter diameter and larger) provides unsurpassed sensitivity and spectral and spatial resolution. Technological advances in a number of key areas of telescope design and construction optimize the telescopes' imaging capabilities and infrared performance, as well as the ability to rapidly reconfigure the attached instrumentation in response to changing atmospheric conditions.



The Gemini South telescope in Chile prepares for the beginning of observation. The telescope is visible through the three-story-high vents on the rotating dome, which permit air flow across the telescope to provide good image quality. *Credit: Gemini Observatory/AURA.*

The Gemini telescopes help educate and train U.S. astronomy and engineering students. An estimated 10 percent of the roughly 500 U.S. users per year are students. Gemini is also providing a focus for public outreach and high school student training in all the partner countries, including "sister city" arrangements between Hilo, Hawaii and La Serena, Chile, involving students and teachers at high school and elementary school levels. Gemini staff members also provide guidance and support to the Imiloa Science Center, a public astronomy and cultural center in Hilo, Hawaii.

Total Obligations for the Gemini Observatory

(Dollars in Millions)

	FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request	ESTIMATES[1] FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Operations & Instrumentation	$21.57	$22.07	$19.59	$21.61	$21.61	$21.61	$21.61	$21.61

[1] Outyear funding estimates are for planning purposes only. The current cooperative agreement ends in FY 2016.

With the withdrawal of the U.K. at the end of calendar year (CY) 2012, the international partnership that operates Gemini now consists of the U.S., Canada, Australia, Chile, Argentina, and Brazil. Construction of the telescopes and their instrumentation used a large number of industrial entities in these and other countries, with areas of specialization that included large and/or complex optical systems, aerospace, electronics, engineering, etc. Continued involvement of such industries is part of the instrumentation and facilities renewal activities included in the operating budget of Gemini Observatory.

Peer-review telescope allocation committees provide merit-based telescope time but no financial support. NSF does not provide awards targeted specifically for use of Gemini. Many U.S. users are supported through separate NSF or NASA grants to pursue scientific programs that require the use of Gemini.

Laser guide star systems, which greatly improve the telescopes' ability to correct for atmospheric blurring, are available for both telescopes, with the laser on Gemini North in routine use. The advanced "multi-conjugate" adaptive optics system on Gemini South is currently in science verification, the final commissioning phase prior to routine use. The laser system yields crisp images over a substantially larger field of view than any other astronomical adaptive optics system in the world. Several new instruments are in various states of development. A high-performance infrared spectrometer is once again available for science observations following refurbishment; and the Gemini Planet Imager, an advanced camera for the southern telescope designed to directly detect planets around nearby stars, is scheduled to arrive at the telescope in early CY 2013.

The 2012 Portfolio Review Committee of the NSF Division of Astronomical Sciences (AST) ranked Gemini Observatory to be a critical component of our Nation's future astronomical research resources, and recommended that the U.S. retain a majority share in the international partnership for at least the next several years. However, given the constrained budget scenarios that were considered, the review committee suggested that this should be achieved with a maximum U.S. contribution of $17.0 million per year to the operations component of Gemini in 2017 and beyond. The committee also recommended that the component of Gemini funding that is set aside for major instrumentation should be competed against other similarly-sized projects in a new mid-scale program administered by AST. Both pieces of advice are complicated by the need for long-term commitments to the international Gemini partnership and (in the case of instrumentation) the intersection with needs of other U.S. national components, so decisions regarding their implementation have not yet been made.

The FY 2014 Request includes the full U.S. contribution to general operations committed in the Gemini international agreement (which totals about $17.40 million in FY 2014), but a somewhat reduced contribution to the Instrument Development Fund compared to the long-term international planning goals. Budget projections for FY 2015 represent a level of effort adopted by the Gemini Board and NSF for planning purposes. Flat funding is assumed thereafter, following the expiration of the Gemini current cooperative agreement. These future requirements will be considered in the context of NSF's overall review of the 2012 Portfolio Review and discussion of the post-2015 international agreement with Gemini partners.

Management and Oversight

- NSF Structure: NSF has one seat on the Gemini Board and an additional NSF staff member serves as the executive secretary to the board. Programmatic management is the responsibility of an assigned NSF program manager for Gemini in the Division of Astronomical Sciences in the Directorate for Mathematical and Physical Sciences. The program manager approves funding actions, reports and contracts, and conducts reviews on behalf of the Gemini partnership.
- External Structure: The Observatory is governed by the Gemini Board, established by the International Gemini Agreement signed by the participating agencies. NSF serves as the executive agency for the partnership, carrying out the project on their behalf. With the withdrawal of the U.K., the U.S. now holds six of the 13 seats on the Gemini Board (including the NSF seat mentioned above). Gemini is currently managed by Associated Universities for Research in Astronomy (AURA), Inc., on behalf of the partnership through a cooperative agreement with NSF. AURA conducts its own management reviews through standing oversight committees, such as the AURA Observatory Council for Gemini.
- Reviews: NSF conducts periodic reviews of the management and Observatory programs as requested by the Gemini Board. The most recent mid-term management review was held in September 2008. In addition, NSF conducted a Business System Review of the Observatory in March 2009. The current cooperative agreement to AURA was awarded after a renewal proposal review in March 2011 and extends through December 31, 2015.

Renewal/Recompetition/Termination

With the withdrawal of the U.K. from the partnership effective December 31, 2012, and the remaining Gemini partner countries having decided to not increase their financial contributions nor to pursue a replacement partner, the operations model of the Observatory is being adjusted to accommodate an approximately 24 percent reduction in operations budget. Commensurate with the reduced funding, total staffing of Gemini Observatory is slated to contract from its current level of 195 to 151 employees over the next three years. All partners, with the exception of the U.K., certified their commitment to this objective by renewing the International Agreement through the end of CY 2015.

The current NSF cooperative agreement to AURA for managing Gemini Observatory through the end of CY 2015 includes the transition to the new operations model. Reductions in project scope that accompany the decline in budget include a reduced instrument complement available on each telescope, a reduction in manpower for the scheduling queue, decreased development and outreach activities, and a tighter operational focus on serving the partner user communities vs. internal scientific research activities. The funding recommendation for this plan was approved by the National Science Board in February 2012.

At present, NSF is beginning the process of competition for the next management agreement for Gemini Observatory, which will take effect on January 1, 2016. All international partners with the exception of Australia (currently a 6.3 percent partner) have re-affirmed their commitment to the Gemini partnership for the post-2015 period, and Australia has expressed their desire to purchase observing time on Gemini on a year-by-year basis thereafter. The Gemini Board is discussing an approach to finding another partner to replace Australia after 2015.

GEODETIC FACILITIES FOR THE ADVANCEMENT OF GEOSCIENCE AND EARTHSCOPE

$12,700,000
-$480,000 / -3.6%

Geodetic Facilities for the Advancement of Geoscience and EarthScope

(Dollars in Millions)

FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request	Change over FY 2012 Enacted Amount	Change over FY 2012 Enacted Percent
$11.92	$13.18	$12.70	-$0.48	-3.6%

The Geodetic Facilities for the Advancement of Geoscience and EarthScope (GAGE) comprise a distributed, multi-user, national facility for the development, deployment, and operational support of modern geodetic instrumentation to serve national goals in basic research and education in the Earth sciences with a focus on studies of Earth's surface deformation at many scales with unprecedented temporal and spatial resolution. GAGE facilities support fundamental research and discovery on continental deformation, plate boundary processes, the earthquake cycle, the geometry and dynamics of magmatic systems, continental groundwater storage, and hydrologic loading. GAGE is managed and operated for NSF by UNAVCO, Inc., a consortium of 104 U.S. universities and non-profit institutions with research and teaching programs in geophysics and geodesy and 78 associate members from foreign institutions. GAGE will be formed in late FY 2013 from part of the EarthScope program and UNAVCO. FY 2012 and FY 2013 funding shown in all tables presented here have been restated for comparative purposes.

Total Obligations for GAGE

(Dollars in Millions)

	FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request	ESTIMATES[1] FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Operations and Maintenance	$11.92	$13.18	$12.70	$12.70	$12.70	$12.70	$12.70	$12.70

[1] Outyear funding estimates are for planning purposes only. The new cooperative agreement begins in FY 2013.

The ability to determine position with respect to a well-constrained terrestrial reference frame using space geodetic techniques has, over the last three decades, improved to submillimeter capability. Space geodesy applications are extremely broad and expanding to include important societal research on earthquake and tsunami hazards, volcanic eruptions, hurricanes, coastal subsidence, wetlands health, soil moisture, groundwater distribution, and space weather. Applications of geodetic techniques to understanding the complex interplay between climate change, continental ice sheet and mountain glacier dynamics, crustal isostatic adjustments, and sea level change is of foremost relevance to current global issues confronting humanity.

To serve the research needs of the broad Earth science community, GAGE is organized under three primary Service Areas and two Special Emphasis Areas:

- **Geodetic Infrastructure**
  - The EarthScope Plate Boundary Observatory (PBO) includes more than 1,100 continuous Global

Positioning System (GPS) stations distributed across the United States, and concentrated on the active plate boundaries in the western contiguous U.S. and southern Alaska. PBO also includes 75 borehole strainmeters and 78 borehole seismometers deployed along the San Andreas Fault and above the Cascadia subduction zone and volcanic arc. Tiltmeters (26) and pore pressure sensors (22) are also collocated with the other borehole instruments.

- Global GPS Arrays outside of the PBO footprint are supported by GAGE in partnership with investigators. Nearly 600 continuous GPS observations from around the world are maintained, monitored, and data compiled into the GAGE data system. GAGE supports 61 of the over 250 GPS sites in the National Aeronautics and Space Administration (NASA)-supported Global Navigation Satellite System (GNSS) array that supports satellite orbit and clock corrections and the refinement of the International Terrestrial Reference Frame (ITRF). GAGE is also developing a 100 station Caribbean region GPS and meteorological sensor network (COCONet) to support tectonic, volcano, tropical storm, and sea level change investigations.
- Community GPS receiver and geodetic technology pool includes a pool of over 450 GPS receivers, ancillary equipment, and five terrestrial laser scanners (TLS), which can be used by investigators for short- and long-term deployments on qualified research projects
- Polar Networks supports GAGE's polar GPS networks in Antarctica (ANET) and Greenland (GNET) and development of specialized GPS monumentation, power, and telemetry solutions for use in harsh environments. GAGE also provides portable campaign deployment geodetic instrumentation, training, and field support for experiments in the polar regions. Additional supplemental funding for these activities is provided through the Division of Polar Programs (PLR).
- Investigator Project Support includes project management, field engineering, and technical support services to plan and execute GPS surveys and permanent station installations. GAGE also maintains a staff focused on geodetic technology equipment testing services to evaluate new geodetic technologies and improve performance for science applications.

- **Geodetic Data Services**
  - Geodetic Data Services manages an archive of over 70 terabytes of GPS, laser scanning, Synthetic Aperture Radar (SAR) and borehole geophysical instruments from all GAGE components including EarthScope PBO, global continuous GPS networks, and campaign GPS observations; operates automated and manual systems to ensure the quality of all data stored in the archive; and provides systems to give the national and international research community with timely access to these data. The archive of SAR imagery maintained and distributed by GAGE to support interferometric SAR imagery of continuous surface deformation at scales of 100s to 1,000 km is complementary to discrete GPS measurement of displacement. As the U.S. currently has no civilian spaceborne SAR sensor, UNAVCO, as the manager of GAGE, brokers for cost-effective community access to the SAR imagery acquired by foreign SAR satellite systems.

- **Education and Community Engagement**
  - The GAGE Education and Community Outreach (ECE) Program enables audiences beyond geodesists to access and use geodetic data and research for educational purposes, including technical short courses, student internships, web-based materials, and programs for strengthening workforce development and improving diversity in the geosciences.

- **Special Emphasis Areas**
  - Community Activities include scientific and technical workshops that bring together the international seismic community and publications designed to communicate GAGE activities and results to the community.

- External Affairs maintains outreach efforts to policymakers and planning for coordination with the international geodesy community.

.Besides its role in providing the observational data essential for basic Earth science research, GAGE also plays a significant role providing geodetic infrastructure support to NASA investigators and the international community through activities in maintaining a subset of the Global GNSS Network (GGN); which supports the refinement of the ITRF and corrections to satellite orbits and clocks, all contributing to the capability for millimeter-level geodetic positioning, subtle observations of Earth's time-varying gravity field and detection of annual millimeter-level changes in sea level.

Commercial surveyors and engineering firms download GAGE facility real-time GPS data daily to support precision positioning. The economic impact of this service to the commercial sector has not been quantified, but is likely substantial.

The EarthScope, Instrumentation and Facilities Programs in the Division of Earth Sciences (EAR); and Programs in the Arctic and Antarctic sections of the Division of Polar Programs (PLR) provide most of the funds, totaling approximately $15.0 million per year, for NSF-sponsored research making use of GAGE. These funds permit deployment of portable geodetic instruments and use of data managed by Geodetic Data Services to solve major Earth science problems.

Management and Oversight

- NSF Structure: EAR, through its Instrumentation & Facilities Program (IF), provides general oversight of GAGE to help assure effective performance and administration. The program also facilitates coordination of GAGE programs and projects with other NSF-supported facilities and projects, and with other federal agencies, and evaluates and reviews the performance of UNAVCO in managing and operating GAGE. The Deep Earth Processes section head and division director in EAR provide other internal oversight.
- External Structure: GAGE is managed and operated by UNAVCO, which is incorporated as a non-profit consortium representing 104 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 seven members of the UNAVCO Board of Directors, five 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, CO.
- Reviews: All major ongoing geoscience facilities routinely undergo mid-award reviews of their management, in addition to peer review of proposals for new or continued support. The formal NSF merit review of the 5-year proposal for the GAGE facility took place in 2012 and 2013 and was also the most recent review of UNAVCO. Although the *ad hoc* reviewers and two independent review panels had a number of specific recommendations at the working level for GAGE, overall the review found that GAGE was a critical facility for U.S. and international Earth sciences. Furthermore, the reviewers found that UNAVCO is a well-managed and effective organization that has, through its commitment to the collection and open dissemination of the highest quality geodetic data, transformed the discipline of geodesy and its geoscience applications.

Renewal/Recompetition/Termination

The initial cooperative agreement for GAGE begins in FY 2013. In FY 2017, in keeping with the phased integration and recompetition plan presented to the National Science Board in December 2009, NSF intends to solicit proposals for a future facility or facilities to support the Earth sciences research and education community currently supported by GAGE and the related Seismological Facilities for the Advancement of Geoscience and EarthScope (SAGE). NSF is currently considering the precise form of this solicitation, and any possible future facility/facilities are currently being considered within NSF and through discussions with the GAGE and SAGE support communities.

ICECUBE NEUTRINO OBSERVATORY

$6,900,000
+$0.00 / 0.0%

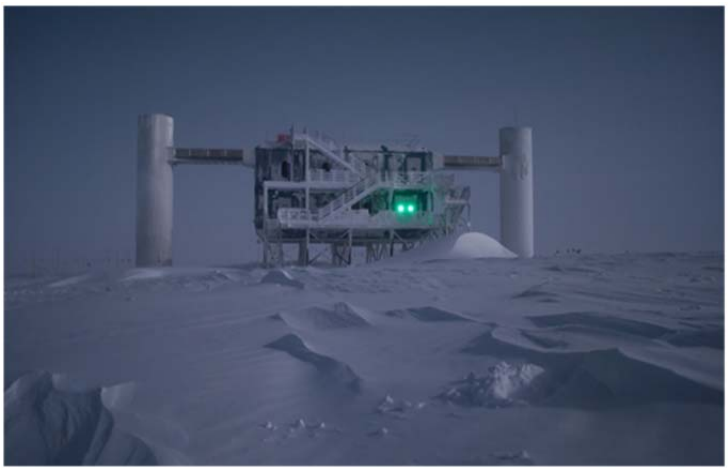
IceCube Neutrino Observatory

(Dollars in Millions)

FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request	Change over FY 2012 Enacted Amount	Percent
$6.90	$6.90	$6.90	-	-

IceCube is the world's first high-energy neutrino observatory, located deep within the ice cap under the U.S. Amundsen-Scott South Pole Station in Antarctica. It represents a new window on the Universe, providing unique data on the engines that power active galactic nuclei, the origin of high-energy cosmic rays, the nature of gamma ray bursts, the activities surrounding supermassive black holes, and other violent and energetic astrophysical processes. Approximately one cubic kilometer of ice is instrumented with photomultiplier (PM) tubes to detect neutrino-induced, charged reaction products produced when a high-energy neutrino interacts in the ice within or near the cubic kilometer fiducial volume. An array of 5160 Digital Optical Modules (DOMs), each containing a PM and associated electronics, is distributed uniformly from 1.5 km to 2.5 km beneath the surface of the South Pole ice cap, a depth where the ice is highly transparent and bubble-free. The energy and arrival direction of high-energy neutrinos ranging in energy from 100 GeV (10^{11} electron Volts [eV]) to 10 PeV (10^{16} eV) are derived from the IceCube data stream.

The Observatory includes a Deep Core Array (DCA). The DCA is composed of eight strings with the DOMs concentrated in the lower-middle part of the array. The tighter spacing of the DOMs allows the Observatory to detect lower energy neutrinos (down to about 10 GeV), thus opening the door to studies of neutrino oscillation measurements and studies of Weakly Interacting Massive Particles (WIMPs) below 250 GeV. In essence, the DCA closes the energy gap between the IceCube Neutrino Observatory and the Super-Kamiokande detector in Japan, and also allows effective observations of high-energy neutrinos entering from the sky of the southern hemisphere.



The IceCube project has transformed one cubic kilometer of natural Antarctic ice into a particle detector. The sensors keep watch for momentary flashes of blue light made by subatomic particles called muons; some are produced in collisions of neutrinos with atomic nuclei inside or near the detector. Since completion in 2010, the IceCube detector has been taking data in its final configuration with an up-time of well over 99 percent. IceCube detects one neutrino every 6 minutes in a background of 2700 cosmic ray muons per second. To handle the high rates, initial analysis of the data is performed by a cluster of computers housed in a two-story building placed on top of the array. The filtered data is sent over geostationary satellites to the IceCube Research Center at the University of Wisconsin. *Credit: IceCube Collaboration.*

Total Obligations for IceCube

(Dollars in Millions)

	FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request	ESTIMATES[1] FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
R&RA Obligations:								
Operations & Maintenance (MPS)	$3.45	$3.45	$3.45	$3.45	$3.45	$3.45	$3.45	$3.45
Operations & Maintenance (GEO)	3.45	3.45	3.45	3.45	3.45	3.45	3.45	3.45
Subtotal, R&RA Obligations	6.90	6.90	6.90	6.90	6.90	6.90	6.90	6.90
MREFC Obligations:								
Implementation	1.52	-	-	-	-	-	-	-
Subtotal, MREFC Obligations	1.52	-	-	-	-	-	-	-
TOTAL Obligations	**$8.42**	**$6.90**	**$6.90**	**$6.90**	**$6.90**	**$6.90**	**$6.90**	**$6.90**

Totals may not add due to rounding.

[1] Outyear funding estimates are for planning purposes only. FY 2015 is the final year of the current cooperative agreement. Funding beyond FY 2015 asssumes continued operation of the facility.

The IceCube Neutrino Observatory is led by the University of Wisconsin (UW) and was constructed with support from four countries (U.S., Belgium, Germany, and Sweden). The science collaboration is much broader, currently consisting of 16 U.S. institutions and 22 institutions in nine other countries (Germany, Belgium, Sweden, New Zealand, Australia, Canada, Japan, Switzerland, and the United Kingdom). NSF's foreign partners contribute a *pro rata* share of operations and maintenance costs based on the number of PhD-level researchers involved. IceCube construction was successfully completed at the South Pole on December 18, 2010.

Management and Oversight

- NSF Structure: Oversight of the IceCube Neutrino Observatory is the responsibility of the Geosciences Directorate's Division of Polar Programs (PLR). Support for operations and maintenance, research, and education and outreach is shared by PLR and the Directorate for Mathematical and Physical Sciences (MPS) Physics Division, as well as other organizations and international partners. NSF provides oversight through regular site visits by NSF managers and external reviewers.
- External Structure: The UW management structure for IceCube includes leadership by the project's Principal Investigator and a project director. At lower levels, project management includes international collaboration representatives, as well as participation by staff at collaborating U.S. institutions. UW has in place an external Scientific Advisory Committee and a Software and Computing Advisory Panel that meet annually and provide written advice to the project. UW leadership, including the Chancellor, provides additional awardee-level oversight.
- Reviews: NSF will conduct a review of operations, management, and science in May 2013.

Operations Costs

Full operations and maintenance in support of scientific research began in FY 2011. The associated costs are and will continue to be shared by the partner funding agencies – U.S. (NSF) and non-U.S. – proportional to the number of PhD researchers involved (currently about 55:45). Since total annual costs are about $13.0 million, the current U.S. share of full science operations and maintenance is $6.90 million.

Support for U.S. institutions working on more refined and specific data analyses, data interpretation

(theory support), and instrumentation upgrades is provided through the Research and Related Activities (R&RA) account in response to merit-reviewed proposals.

The general operations of South Pole Station, reported in the Polar Facilities and Logistics narrative, also contribute to supporting IceCube. The cost of IceCube operations shown in the table herein includes only those that are project-specific and incremental to general South Pole Station operations. The expected operational lifespan of the IceCube Neutrino Observatory is 25 years beginning in FY 2011.

Education and Outreach

IceCube provides a vehicle for helping to achieve national and NSF education and outreach goals. Specific outcomes include the education and training of next-generation leaders in astrophysics, including undergraduate students, graduate students, and postdoctoral research associates; K-12 teacher scientific/professional development, including development of new inquiry-based learning materials and using the South Pole environment to convey the excitement of astrophysics, and science generally, to K-12 students; increased opportunity for involvement of students in international collaborations; increased diversity in science through partnerships with minority institutions; and enhanced public understanding of science through broadcast media and museum exhibits (such as the Adler Planetarium) based on IceCube science and the South Pole environment. NSF supports evaluation and measurement-based education and outreach programs under separate grants to universities and other organizations that are selected following standard NSF merit review.

Renewal/Recompetition/Termination

The current IceCube Maintenance & Operations award expires in September 2015. Prior to expiration, the award will be re-competed in accordance with NSF policy.

THE INTERNATIONAL OCEAN DISCOVERY PROGRAM

$50,000,000
+$5,600,000 / 12.6%

International Ocean Discovery Program

(Dollars in Millions)

FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request	Change over FY 2012 Enacted Amount	Change over FY 2012 Enacted Percent
$51.68	$44.40	$50.00	$5.60	12.6%

The International Ocean Discovery Program (IODP), beginning in FY 2014, replaces the Integrated Ocean Drilling Program, which began in FY 2004 and is an expanded successor program to the Ocean Drilling Program. The new IODP represents an international partnership of the scientists, research institutions, and funding organizations of 26 nations to explore the evolution and structure of Earth as recorded in the ocean basins. The new program management structure is streamlined and focused on maximizing facility efficiency, while retaining the intellectual cooperation and exchange of the previous drilling program. NSF, the Ministry of Education, Culture, Sport, Science and Technology (MEXT) of Japan, and the European Consortium for Ocean Research Drilling (ECORD) will continue to provide drilling platforms. IODP platforms provide sediment and rock samples (cores), in-situ monitoring, sampling, and measurement from borehole observatories, shipboard and shorebased descriptive and analytical facilities, downhole geophysical and geochemical measurements (logging), and opportunities to conduct experiments to determine in-situ conditions beneath the sea floor.

JOIDES Resolution underway for a science expedition, March 10, 2009. *Credit: NSF*

Total Obligations for IODP

(Dollars in Millions)

	FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request	ESTIMATES[1] FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Operations and Maintenance	$51.68	$44.40	$50.00	$50.00	$50.00	$50.00	$50.00	$50.00

Totals may not add due to rounding.

[1] Outyear funding estimates are for planning purposes only. Funding for FY 2015 through FY 2019 is estimated assuming renewal of the program.

Annual operations and maintenance support for IODP includes the costs of operating the *JOIDES Resolution*, the primary platform of IODP. The *JOIDES Resolution* is leased from an offshore drilling contractor under a long-term contract with favorable day rates. Another commercial contractor provides downhole-logging services. Maintaining databases, preparing scientific publications emerging from IODP expeditions, and management of the international program are additional IODP science integration costs, made minimal to NSF because of international contributions to IODP. In addition, NSF provides

support for U.S. scientists to sail on IODP drilling platforms and to participate in IODP advisory panels through an associated grants program. The annual costs for the associated science integration and science support (not included in the table above) are approximately $12.0 million.

The new IODP scientific program includes emphasis on the following research themes:

- Climate and Ocean Change: Reading the Past, Informing the Future;
- Biosphere Frontiers: Deep Life, Biodiversity, and Environmental Forcing of Ecosystems;
- Earth Connections: Deep Processes and Their Impact on Earth's Surface Environment; and
- Earth in Motion: Processes and Hazards on Human Time Scales.

Starting in FY 2013 under the International Ocean Discovery Program, an umbrella forum provides a venue for all IODP entities to exchange ideas and views on the scientific progress of the program. In the simplified new IODP management structure, each drillship is governed by independent facility boards, each unique and optimized for their respective drilling platform. In the case of the *JOIDES Resolution* Facility Board (JRFB), three advisory panels review proposals and give science and safety advice. A U.S. scientist leads the JFRB, with other members from the scientific community, funding agencies, and the facility operator.

IODP participants include the United States, Japan, ECORD (Austria, Belgium, Canada, Denmark, Finland, France, Germany, Iceland, Ireland, Italy, the Netherlands, Norway, Poland, 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.

Over 2,400 scientists from over 42 nations have participated on Ocean Drilling Program and Integrated Ocean Drilling Program expeditions since 1985, including approximately 1,120 U.S. scientists from over 150 universities, government agencies, and industrial research laboratories. Samples and data have been distributed to around 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 the IODP under the NSF Ocean Drilling Program. NSF's Ocean Drilling Program is located within the Marine Geosciences Section, with several program officers dedicated to its oversight. One of the program officers serves as the contracting officer's technical representative for the Central Management Office (CMO) contract and the System Integration Contractor (SIC) contract.
- External Structure: NSF and MEXT have signed a Memorandum of Cooperation, which identifies procedures for joint management of a contract to an IODP CMO. A non-profit corporation of U.S., Japanese, and other international institutions (IODP Management International, Inc.) has been contracted by NSF for the CMO activity. The CMO coordinates and supports scientific planning, drilling platform activity, data and sample distribution, and publication and outreach activities through its management of commingled international science funds, collected and provided by NSF. Drillship providers are responsible for platform operational management and costs. NSF provides a light drillship through a contract with the U.S. systems integration contractor, an alliance formed by the Consortium for Ocean Leadership, Inc. (COL) together with subcontractors at Texas A&M University and Lamont-Doherty Earth Observatory, Columbia University. MEXT manages its drillship through the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), while the British Geological Survey manages ECORD drilling contributions.

- Scientific advice and guidance for IODP is provided through the science advisory structure (SAS), recently streamlined and made more efficient in response to independent, contractual management review. The SAS now consists of a Science Implementation and Policy Committee (SIPCOM), a Proposal Evaluation Panel (PEP), and a series of service panels. The CMO is responsible for coordinating the SAS committee and panels, and for integrating the advice from the SAS into drilling and operational guidance for IODP. Representation in the SAS is proportional to IODP member financial contributions.
- Reviews: Both the CMO and SIC contracts call for management reviews every three years by independent, external panels. Both the SIC and CMO contracts underwent external review in FY 2010.[23] Performance under both contracts will be reviewed again in FY 2013. Reviews for each expedition are carried out on a regular basis to evaluate operational and scientific performance, with review of scientific progress in broader thematic areas conducted by an independent panel every several years.

Renewal/Recompetition/Termination

Originally scheduled to end in FY 2013, the contract to operate IODP was extended through FY 2014 to allow for competitive selection of an operator for the *JOIDES Resolution* under a cooperative agreement. Pending selection of an acceptable proposal that fits within broader OCE priorities and National Science Board approval, a cooperative agreement supporting the *JOIDES Resolution* is expected to be in place to provide seamless FY 2015 IODP science operations. This cooperative agreement will contain 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.

To facilitate and support the activities of U.S. scientists participating in IODP activities, an IODP Science Support Office has also been funded. Management of this office is also being competitively solicited, with selection of an awardee expected in summer 2013.

The *JOIDES Resolution* Operations and Science Support Cooperative Agreements will contain a provision for annual external review of performance by an independent panel. A more intensive mid-award review at the end of the third year, in FY 2017, will consider whether the cooperative agreement should be extended or re-competed. NSF and its IODP partners contributing funds to *JOIDES Resolution* operations are negotiating formal agreements, which identify rights of participation on the *JOIDES Resolution* and its facility board and advisory panels based upon partner financial contributions to *JOIDES Resolution* operations. A brief letter of understanding regarding berthing exchange is being negotiated between NSF and the Japanese Agencies MEXT and the Japan Agency for Marine-Earth Science and Technology (JAMSTEC). Similarly, MEXT manages its drillship through JAMSTEC, while the British Geological Survey manages ECORD drilling contributions.

[2] www.iodp-usio.org/Publications/IODP_OA_2010.pdf
[3] www.iodp.org/triennium-review/

LARGE HADRON COLLIDER

$18,000,000
$0.00 / 0.0%

Large Hadron Collider
(Dollars in Millions)

FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request	Change over FY 2012 Enacted Amount	Change over FY 2012 Enacted Percent
$18.00	$18.00	$18.00	-	-

Totals may not add due to rounding.

The Large Hadron Collider (LHC), an international project at the CERN laboratory in Geneva, Switzerland, is the premier facility in the world for research in elementary particle physics. The facility consists of a superconducting particle accelerator providing two counter-rotating beams of protons, approximately 16.5 miles in circumference, with each beam to have a design energy up to 7 TeV ($1TeV=10^{12}$ electron volts). It can also provide colliding beams of heavy ions, such as lead. Data-taking with colliding proton beams at 3.5 TeV began in the Spring of 2010; currently the accelerator operates at a beam energy of 4 TeV per beam. Starting in March 2013, the LHC will undergo a 20-month period of extensive repairs and enhancements that will enable it to operate at the full design energy of 7 TeV per beam.

The U.S. is involved in the maintenance and operation of two particle detectors, a Toroidal LHC Apparatus (ATLAS) and the Compact Muon Solenoid (CMS). These have been built to characterize the different reaction products produced in the very high-energy proton-proton collisions that occur in intersection regions where the two beams are brought together. The same detectors are also being used to study the reaction products from heavy ion beam collisions. A total of 45 international funding agencies participate in the ATLAS detector project and 42 in the CMS detector project. NSF and the Department of Energy (DOE) provide U.S. support to both experiments. CERN is responsible for meeting the goals of the international LHC project. The ATLAS and CMS detectors take data approximately 200 days per year. The remaining time is to be used for maintenance and testing. During the 20-month maintenance period noted above, the detectors will also undergo a series of repairs and enhancements to prepare for higher-energy operations.

The successful operation during 2012 of the accelerator complex, the ATLAS and CMS detectors, and the world-wide LHC computing grid culminated in the first major discovery at the LHC. On July 4, 2012, the CMS and ATLAS collaborations announced the discovery of a particle consistent with the long-sought Higgs boson. Further study of the properties of this new particle will reveal whether it is the Higgs boson predicted in the Standard Model of particle physics, which will provide a deeper understanding of the origin of mass of the known elementary particles. The LHC program also 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, and can investigate the possibility that there are extra dimensions in the structure of the universe. 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. Further, innovative education and outreach activities, such as the QuarkNet project, allow high school teachers and students to participate in this project (see www.quarknet.fnal.gov).

Total Obligations for LHC
(Dollars in Millions)

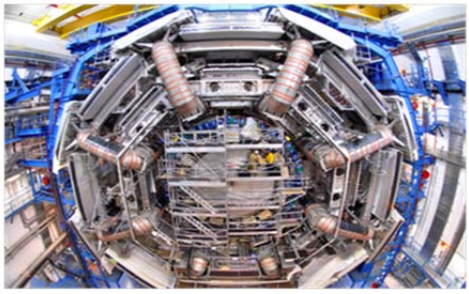
	FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request	ESTIMATES[1] FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Operations and Maintenance	$18.00	$18.00	$18.00	$20.00	$20.00	$20.00	$20.00	$20.00

[1] Outyear funding estimates are for planning purposes only. The current cooperative agreement ends in FY 2016.

The U.S. LHC collaboration continues to be a leader in the development and exploitation of distributed grid-based computing. The LHC grid enables 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.

Major component procurements of warm and superconducting magnets as well as high-speed electronics are made through U.S. industries. In the construction phase, approximately $45.0 million was devoted to materials procurements. In FY 2014 material procurements are estimated to be about $5.0 million, which is included within the $18.0 million detector operating costs.

Both collaborations continue to operate the detectors smoothly and to analyze the collected data efficiently using world-wide computing resources. The LHC experiments are also adapting quickly to the gradual increase in beam energy and the increases in beam intensities. While challenging, these increases significantly enhance the chances of more ground-breaking discoveries at the LHC. During the accelerator shut-down period starting in 2013, the collaborations will carry out needed maintenance on the detectors while continuing to analyze the many Petabytes of data collected in the previous two years.



The ATLAS detector in February 2007. *Credit: CERN.*

Management and Oversight

- NSF Structure: A program director in the NSF Division of Physics (PHY) is responsible for day-to-day project oversight.
- External Structure: U.S. LHC program management is performed through a Joint Oversight Group (JOG), created by the 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 support for operations is provided through cooperative agreements with Princeton University for US-CMS and with Columbia University for ATLAS.
- Reviews: There is one major management/technical review each year with a panel of external, international experts, as well as bi-weekly telephone reviews by NSF/DOE program directors to monitor progress. The next major management/technical review is scheduled for March 2013. Two JOG review meetings per year monitor overall program management.

Renewal/Recompetition/Termination

The LHC project is expected to continue at least through the end of the next decade. In December 2011, new cooperative agreements were negotiated with the ATLAS and CMS collaborations to extend funding for an additional five years to support their role in the international collaborations.

LASER INTERFEROMETER GRAVITATIONAL-WAVE OBSERVATORY — $39,500,000 +$9,100,000 / 29.9%

Laser Interferometer Gravitational-Wave Observatory
(Dollars in Millions)

FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request	Change over FY 2012 Enacted Amount	Change over FY 2012 Enacted Percent
$30.40	$30.40	$39.50	$9.10	29.9%

Totals may not add due to rounding.

Einstein's theory of general relativity predicts that cataclysmic processes involving extremely dense objects in the universe, such as the collision and merger of two neutron stars or black holes, will produce gravitational radiation. Detection of these gravitational waves is of great importance for fundamental physics, astrophysics, and astronomy. The Laser Interferometer Gravitational-Wave Observatory (LIGO), the most sensitive gravitational-wave detector ever built, comprises two main facilities, one in Livingston Parish, LA and one in Hanford, WA. At each facility, a large vacuum chamber with two 4-km arms joined at right angles houses one or more optical interferometers; the Hanford chamber contains a second 2-km interferometer. The interferometers are used to measure minute changes in the distances between mirrors at the ends of the arms caused by a passing gravitational wave. The predicted distortion of space caused by a gravitational wave from a likely source is on the order of one part in 10^{21}, meaning that the expected change over the apparent 4-km length is only on the order of 4×10^{-18} meters, or about 1/1000th the diameter of a proton. The 4-km length for LIGO, the largest for any optical interferometer, was chosen to make the expected signal as large as possible within terrestrial constraints. Looking for coincident signals in all the interferometers simultaneously increases the likelihood for gravitational wave detection.

In April 2008 construction began on the Advanced LIGO (AdvLIGO) Major Research Equipment and Facility Construction (MREFC) project, which is designed to increase the sensitivity of LIGO tenfold. AdvLIGO is being built within the existing LIGO laboratory. LIGO's current and projected operations and maintenance expenses are designed to sustain operation of the LIGO laboratory during the time that the construction is underway. These include support for basic infrastructure costs not directly related to the AdvLIGO construction project, data analysis for the S5 and S6 science runs, maintenance of computational resources for data storage and analysis, research and development for any pre-design costs and risk reduction related to AdvLIGO that are outside the scope of the AdvLIGO project, and education and outreach projects associated with the laboratory.

An aerial view of the Livingston, LA LIGO site. *Credit: Caltech/MIT LIGO Laboratory.*

The LIGO Science Education Center at the Livingston site is the focal point for augmenting teacher education at Southern University and other student teacher activities state wide through the Louisiana Systematic Initiative Program. The LIGO Science Education Center's programs include funding for an external evaluation firm that provides both assistance in aligning future activities with proposed goals and evaluating outcomes.

Substantial connections with industry have been required for the state-of-the-art construction and measurement involved in LIGO projects, with some innovations leading to new products. Interactions with industry include exploring novel techniques for fabrication of LIGO's vacuum system, seismic isolation techniques, ultrastable laser development (new product), high optical power electrooptic components (new products), new ultra-fine optics polishing techniques, and optical inspection equipment (new product).

Total Obligations for LIGO

(Dollars in Millions)

	FY2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request	ESTIMATES[1] FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Operations and Maintenance	$30.40	$30.40	$39.50	$39.50	$41.00	$41.00	$41.00	$41.00

[1] Outyear funding estimates are for planning purposes only. The current cooperative agreement ends in FY 2013.

In 1997 LIGO founded the LIGO Scientific Collaboration (LSC), an open collaboration that organizes the major international groups doing research supportive of LIGO. The LSC now has more than 77 collaborating institutions in 15 countries with more than 870 participating scientists, and LSC membership is growing at a rate of approximately 10 percent per year. A Memorandum of Understanding (MOU) between the LIGO Laboratory and each institution determines the membership responsibilities. The LSC plays a major role in many aspects of the LIGO effort, including research and development (R&D) for detector improvements, R&D for AdvLIGO, data analysis and validation of scientific results, and setting priorities for instrumental improvements at the LIGO facilities. Annual NSF support for science and engineering research directly related to LIGO activities through ongoing research and education programs is about $5.50 million, provided through the disciplinary programs.

LIGO concluded its initial phase of existence with the S6 science run, which, in addition to the acquisition of science data, also tested technologies that will become part of AdvLIGO. This run began in July 2009 and ended in October 2010. The detector sensitivity was about 30 percent higher than that during the previous S5 run, making the S6 science run both a scientific success and a valuable testbed for AdvLIGO. At the end of this run the LIGO instruments were turned over to the AdvLIGO project for decommissioning and for installation of advanced components. LIGO and the LSC are currently analyzing the data from the S6 run.

AdvLIGO construction will conclude in FY 2014 with anticipated first commissioning of the upgraded facility to begin in early FY 2015. During the AdvLIGO construction period, normal operations costs were reduced as attention was focused on construction. With the completion of the AdvLIGO project, LIGO operations will revert from the lower level of operations funding to the $33.0 million in operations funding prior to the onset of construction in FY 2007, plus the increase support required to manage more sophisticated instruments installed as part of the construction project.

For more information on AdvLIGO, see the MREFC chapter.

Management and Oversight

- NSF Structure: NSF oversight is coordinated internally by the LIGO program director in the NSF Division of Physics (PHY), who also participates in the PHY AdvLIGO Project Advisory Team, comprised of staff from the NSF Office of General Counsel, Office of Legislative and Public Affairs, International Science and Engineering , as well as the the Deputy Director for Large Facility Projects in the Office of Budget, Finance, and Award Management.
- External Structure: LIGO is managed by the California Institute of Technology under a cooperative agreement. The management plan specifies significant involvement by the user community, represented by the LSC, and collaboration with the other major gravitational-wave detector activities in Asia, Europe, and Australia. External peer-review committees organized by NSF help provide oversight through an annual review.
- Reviews:
  - AdvLIGO Baseline Review, May-June 2006
  - LIGO Annual Review, November 2006
  - AdvLIGO Baseline Update Review, June 2007
  - LIGO Annual Review and LIGO FY 2009-2013 Operations Proposal Review, November 2007
  - LIGO Business Systems Review (BSR), final report issued March 2008
  - LIGO Annual Review, November 2008
  - AdvLIGO Annual Review, April 2009
  - LIGO Annual Review and AdvLIGO Interim Review, December 2009
  - AdvLIGO Annual Review, April 2010
  - LIGO Annual Review and AdvLIGO Interim Review, December 2010
  - AdvLIGO Annual Review, April 2011
  - LIGO Annual Review and AdvLIGO Interim Review, November 2011
  - LIGO Annual Review and AdvLIGO Interim Review, November 2012

Installation of a quantum-mechanical squeezing experiment at LIGO in 2011. The temporary experiment allowed LIGO to increase its sensitivity by more than 20 percent over most of its frequency range. Such research is conducted by LIGO Laboratory and the LIGO Scientific Collaboration to reduce risk in the Advanced LIGO construction project. *Credit: Caltech/MIT LIGO Laboratory.*

Renewal/Recompetition/Termination

LIGO began operating under a new five-year cooperative agreement in early FY 2009. As a condition of approval of this award (and a possible future award), the National Science Board stipulated that the operation of LIGO be recompeted no later than 2018. The projected lifetime of the LIGO facility is 20 years.

NATIONAL HIGH MAGNETIC FIELD LABORATORY

$32,640,000
+$6,840,000 / 26.5%

National High Magnetic Field Laboratory
(Dollars in Millions)

FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request	Change over FY 2012 Enacted Amount	Change over FY 2012 Enacted Percent
$26.80	$25.80	$32.64	$6.84	26.5%

Totals may not add due to rounding.

The National High Magnetic Field Laboratory (NHMFL) is operated by Florida State University (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 core areas of condensed matter and material physics, materials science and engineering, chemistry and various areas of the biological and biochemical sciences, as well as work on energy and the environment. It is the world's premier high magnetic field laboratory with a comprehensive assortment 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; external users number about 1,100 per year as well as faculty and staff at the three collaborating institutions.

The lab is an internationally recognized leader in magnet design, development, and construction, including the development of conducting and superconducting materials. Many of the unique magnet systems were designed, developed, and built by the Magnet Science and Technology (MS&T) Division of the NHMFL. In 2012, the lab set the world's record for the highest nondestructive pulsed magnetic field at 100.75 tesla. The 45 tesla hybrid magnet currently provides the highest steady-state magnetic fields in the world. Both magnets enable scientists to get new insights into the electronic structures of novel materials such as graphene, topological insulators, high temperature superconductors, and more. MS&T works with industry and other international magnet laboratories on a variety of technology projects. These include analysis, design, component development and testing, coil fabrication, cryogenics, system integration, and testing.

A $15.0 million award funded by the American Recovery and Reinvestment Act of 2009 (ARRA) through the NSF Division of Chemistry enabled the purchase of a 21 tesla magnet for the construction of a Fourier Transform Ion Cyclotron Resonance Spectrometer (FT-ICER) that will be world-record holding in sensitivity and selectivity. This instrument will be capable of analyzing chemical samples of unprecedented complexity, such as biological fluids and biofuels, and with unprecedented resolution and speed. This new capability will have high impact in several areas including chemistry, molecular biology, and heavy petroleum analysis. Construction and factory testing of the 21 tesla magnet are scheduled for completion in May of 2013, and delivery to the NHMFL FT-ICR facility in June 2013. Subsequent instrument development will then follow for approximately six to twelve months.

The FY 2014 Request will allow the facility to continue operations, focus on magnet development, and strengthen education, training, user support, and in-house research. It is consistent with prior levels for this activity. (The FY 2012 level is relatively lower due to about $6.0 million in forward funding provided by previous appropriations).

Total Obligations for NHFML

(Dollars in Millions)

	FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request	ESTIMATES[1] FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Operations and Maintenance	$26.80	$25.80	$32.64	$33.67	$34.66	$35.79	$35.79	$35.79

[1] Outyear funding estimates are for planning purposes only. The current cooperative agreement ends in December 2017.

Current magnet development at NHMFL focuses on new energy-saving, high-field magnet technologies, including the design, development and construction of all-superconducting magnets based on high-temperature superconductor technology. The goal is to develop high-field magnets for the NHMFL user program that double current energy-efficiency. NHMFL collaborates with more than 60 private sector companies, national laboratories, and federal centers, including those supported by the Department of Energy (DOE), such as the Spallation Neutron Source and the Advanced Photon Source at Argonne National Laboratory. International collaboration includes magnet development with the Helmholtz-Zentrum Berlin (HZB) (previously known as the Hahn-Meitner-Institute Berlin), the International Thermonuclear Experimental Reactor (ITER) in France, and national magnet labs in France, the Netherlands, Germany, and China.

NHMFL provides a unique interdisciplinary learning environment. The Center for Integrating Research and Learning at NHMFL conducts education and outreach activities, which include a Research Experience for Undergraduates program, summer programs for teachers, a summer camp for middle school girls, and activities to raise the scientific awareness of the general public.

Management and Oversight

- NSF Structure: NHMFL is supported by the Division of Materials Research (DMR) and the Division of Chemistry (CHE) in the NSF Directorate for Mathematical and Physical Sciences (MPS). DMR is the steward supporting the broad mission of the facility, providing 95 percent of the funds. CHE supports the Fourier Transform Ion Cyclotron Resonance (FT-ICR) Laboratory and provides about 5 percent of funding. Primary responsibility for NSF oversight is with the national facilities program director in DMR, with help from the FT-ICR program director in CHE.
- External Structure: A consortium of the three institutions (FSU, UF, and LANL) operates NHMFL under a cooperative agreement. FSU, as the signatory of the agreement, has the responsibility for appropriate administrative and financial oversight and for ensuring that operations of the laboratory are of high quality and consistent with the objectives of the cooperative agreement. The principal investigator serves as the NHMFL director and reports to the FSU Vice President for Research. Four senior faculty members are co-principal investigators. The NHMFL director receives guidance primarily from the NHMFL executive committee and the NHMFL science council. He also receives recommendations from an external advisory committee, the NHMFL diversity committee, and the users' executive committee.
- Reviews: NSF conducts annual external reviews, which assess 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 a panel of experts from the community, representatives from other federal agencies such as DOE and the National Institutes of Health (NIH) attend these site visits. Recent and upcoming reviews include:
  - Business Systems Review (BSR), final report issued in September 2009.

- Renewal Review by external panel of site visitors, December 2011.
- Annual Site Review by external panel of site visitors, December 2013.
- NSF initiated a broad-based community study through the National Research Council on opportunities in high magnetic field research. This report, expected in May 2013, will inform future plans for investments in this area.

Renewal/Recompetition/Termination

A comprehensive renewal review was conducted in FY 2012. The National Science Board approved a five-year renewal award not to exceed $168.38 million for FY 2013-2017.

NATIONAL NANOTECHNOLOGY INFRASTRUCTURE NETWORK **$15,460,000**
-$400,000 / -2.5%

National Nanotechnology Infrastructure Network

(Dollars in Millions)

FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request	Change over FY 2012 Enacted Amount	Percent
$16.00	$15.86	$15.46	-$0.40	-2.5%

The National Nanotechnology Infrastructure Network (NNIN) will complete its second and final five-year funding period in FY 2013. In FY 2014, the National Science Foundation will establish, through an open competition, a Next-Generation National Nanotechnology Infrastructure Network (NG NNIN) for Fiscal Years 2014-2018. NG NNIN will build on the concept of NNIN in comprising multiple university sites to form an integrated national network of user facilities supporting research and education across diverse disciplines in nanoscale science, engineering, and technology. NG NNIN will continue to provide users across the Nation with access, both on-site and remotely, to leading-edge tools, instrumentation, and expertise for fabrication, synthesis, characterization, design, simulation, and integration. In addition, the NG-NNIN will offer a broader scope and user base than the current network of facilities through the following:

- A user base that is broadened to include communities of environmental sciences, geosciences, and biosciences;
- Availability of new leading-edge fabrication capability;
- Capabilities to create complex and three-dimensional nanoscale systems through heterogeneous integration;
- Capabilities to build nanoscale systems across multiple dimensional scales through hierarchical design and fabrication;
- Capabilities for fabrication in soft matter including potentially biological interfaces;
- New generations of modeling and simulation along with the use of new design tools to maximize overall understanding and fabrication efficiency;
- Facilities capable of supporting the translation of discovery into prototypical elements suitable for evaluation of manufacturability and proof of business concept;
- Partnerships with industry, government, and other groups to provide specialized capabilities within the network when warranted, including linkages with other networks and federal infrastructure investments;
- Unified program of education and outreach built upon the unique nature of the network and funded at a level commensurate with the goals and directions of the program; and
- Commitment to support and champion environmental responsibility, health, and safety (EHS) by providing direct capabilities including characterization, fabrication, and synthesis.

Total Obligations for NNIN

(Dollars in Millions)

	FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request	ESTIMATES[1] FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Operations and Maintenance	$16.00	$15.36	$15.46	$16.00	$16.00	$16.00	$16.00	$16.00

[1]Outyear funding estimates are for planning purposes only. FY 2014 will be the first year of the cooperative agreement for NG NNIN. Funding beyond FY 2014 assumes continued operation of the facility as the next-generation NNIN, as described in the Renewal/Recompetion/Termination section of this narrative.

NNIN's national user facilities have enabled the Nation's researchers from academia, small and large industry, and government to pursue transformative research, seek new discoveries and applications in a broad range of domains of nanoscale science and engineering, and stimulate technological innovation. The network also has developed the infrastructure and intellectual and institutional capacity needed to examine and address societal and ethical implications of nanotechnology, including issues of environment, health, and safety. The NNIN user facilities have promoted interdisciplinary research by bridging the gap between materials, mechanics, electronics, photonics, biology and diverse fields, and enabling longitudinal pathways from fundamental studies to devices and systems.

NNIN has undertaken, on a national scale, a broad spectrum of innovative activities in education, human resource development, knowledge transfer, and outreach to the science, engineering, and technological communities. Special emphasis has been placed on education and training of a diverse science and engineering workforce that involves non-traditional users and under-represented groups, including women and minorities. NNIN has sought to leverage its capabilities through connections and collaborations with national and industrial laboratories and with foreign institutions. Through such partnerships, joint meetings, and workshops, the network has shared expertise and perspectives, provided specialized training opportunities, coordinated access to unique instrumentation, and transferred newly developed technologies.

NNIN has leveraged research strengths of universities to bring them to the external community. The institutions comprising the NNIN have had strong underlying internal research programs that provided the knowledge base for developing new processes, methodologies, and instrumentation, as well as much of the capital infrastructure. NSF and other agencies independently have awarded research grants to principal investigators who used NNIN facilities to carry out some aspects of their research projects.

In the FY 2009 renewal period, three institutions joined the network, each bringing new capabilities and broadening the user base: the University of Colorado, which focused on research in energy-related problems and in precision sciences that include measurements, standards, and systems; Arizona State University, which focused on organic/inorganic interfaces in electronics, biodesign, implantable devices, flexible electronics, sensors, and outreach to underrepresented communities in the Southwest; and Washington University in St. Louis, whose research focused on nanomaterials and nanosciences for environment, health, and safety. NNIN, through lead efforts at the University of Washington and University of Michigan, also has served as a technology source to facilitate collaboration for ocean sensing infrastructure between the geosciense community and the nanotechnology sensor community.

During NNIN's ninth full year of operation encompassing the period from March 2012 through February 2013, 6,323 unique users (an increase of 4 percent over the previous year period) performed a significant part of their experimental work at NNIN facilities. Of these, 5,270 were academic users (roughly 85 percent graduate students, 7 percent undergraduate students, and 8 percent postdocs) from over 200 academic institutions. In addition, 970 were industrial users, of which 760 were from small companies.

Over 3,300 publications, patents, and patent applications, several of them significant scientific and engineering highlights of the year, resulted from the work of the user community. A major task of staff of NNIN is in training of this user community, particularly graduate students from across the United States, where there is a continuous and significant turnover. A total of 2,081 new users were trained in the vast instrument set, large and small, at the networks facilities.

Management and Oversight

- NSF structure: In preparation for the new award for NG NNIN, NSF will continue to provide oversight under a cooperative agreement with the lead institution. The cognizant program officer for the NNIN activity will reside in the Division of Electrical, Communications and Cyber Systems (ECCS) in the Directorate for Engineering (ENG). The program officer will coordinate NG NNIN oversight with the NG NNIN working group comprised of representatives from all NSF directorates and the Office of International and Integrative Activities. NG NNIN will be reviewed annually through site reviews held at one of the network sites. These reviews will involve an external team of experts selected by the NSF working group.

- External structure: The current NNIN is managed as a cohesive and flexible network partnership through a Network Executive Committee derived from the individual site directors, and the Education/Outreach and Society/Ethics coordinators. The position of Network Director is now held by the director of the Stanford University site. The Network Director provides intellectual leadership for the network and is also responsible, in cooperation with the Network Executive Committee, for developing strategies, operational plans, and coordination of the activities of the network, and serves as the principal contact on behalf of the network with NSF. An external Network Advisory Board meets at least annually and provides independent advice and guidance to the network director and Executive Committee concerning the network's programs, activities, vision, funding allocations, and new directions. The Advisory Board shares its major recommendations with the NSF. The site directors are responsible for local management functions of the individual user facilities, for interfacing with other facilities and with the management team for the overall network, and for connections with the outside communities. NSF anticipates a similar management structure will be established for the NG NNIN.

- Reviews: The first comprehensive annual review of the NNIN was held following an initial 9 months of operation at the Georgia Institute of Technology site in December 2004. The second annual review was held at the University of Texas-Austin site in February 2006. The third annual review was held at the University of Michigan site in May 2007. The fourth annual review was held at the Stanford University site in May 2008. This review also served to evaluate the NNIN renewal proposal for the five-year period FY 2009-2013. A mid-year informational review was held at NSF in October 2009. The sixth annual review was held at the University of Washington site in May 2010. The seventh annual review was held at the University of Colorado-Boulder site in May 2011. The eighth and final annual review of NNIN was held at the Georgia Institute of Technology site in May 2012.

Renewal/Recompetition/Termination

The National Science Board approved NSF's review-based recommendation in December 2008 and authorized renewal of the NNIN award for a final five-year period from FY 2009-2013. In April 2012, NSF convened a Nanotechnology Infrastructure Workshop of recognized national experts to evaluate the needs and appropriate future investments in the national infrastructure for nanotechnology. The workshop report has been used to help prepare the solicitation for the new open competition for NG NNIN. The NG NNIN solicitation NSF 13-521 was released in December 2012, with the intent of making a new 5-year award for FY 2014-2018.

NATIONAL SOLAR OBSERVATORY

$8,000,000
-$1,100,000 / -12.1%

National Solar Observatory

(Dollars in Millions)

FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request	Change over FY 2012 Enacted Amount	Percent
$9.10	$9.10	$8.00	-$1.10	-12.1%

Totals may not add due to rounding.

The National Solar Observatory (NSO) operates facilities in New Mexico and Arizona as well as a coordinated worldwide network of six telescopes specifically designed to study solar oscillations. NSO leads the community in construction of the Advanced Technology Solar Telescope (ATST). (See the Major Research Equipment and Facilities Construction chapter for more information). NSO makes available to qualified scientists the world's largest collection of optical and infrared solar telescopes and auxiliary instrumentation for observation of the solar photosphere, chromosphere, and corona. NSO also provides routine and detailed, synoptic solar data used by many researchers and other agencies through its online archive and data delivery system.

NSO telescopes are open to all astronomers regardless of institutional affiliation on the basis of peer-reviewed observing proposals. In FY 2012, 61 unique observing programs from 20 U.S. and 19 foreign institutions were carried out using NSO facilities. Students carried out 25 percent of these, which included 10 Ph.D. thesis programs. Nearly eleven terabytes of NSO synoptic data were downloaded from the NSO digital archives. Approximately 137 staff members are employed at NSO.

A community-based review of the entire portfolio of the Division of Astronomical Sciences (AST) was completed during FY 2012. Its findings and recommendations will inform future budget allocation and planning activities. Prior to receiving this Portfolio Review report, NSF had instructed NSO to begin divestment of the McMath/Pierce solar telescope on Kitt Peak, thereby accelerating the already-planned divestment by a few years. The Portfolio Review Committee endorsed this decision. In addition, it recommended continued operation of the Dunn Solar Telescope through 2017 and reduced support of the synoptic programs. At this time, NSF is considering the Portfolio Review Committee's recommendations, and no decisions have been made. The impact of the Portfolio Review on long-term funding will be presented in future Requests.

Total Obligations for NSO

(Dollars in Millions)

	FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request	ESTIMATES[1] FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
NSO-Operations	$7.25	$7.25	$6.70	$6.70	$6.70	$6.70	$6.70	$6.70
NSO-Development	1.50	1.50	1.00	1.00	1.00	1.00	1.00	1.00
NSO-Research & Education	0.35	0.35	0.30	0.30	0.30	0.30	0.30	0.30
Total, NSO	**$9.10**	**$9.10**	**$8.00**	**$8.00**	**$8.00**	**$8.00**	**$8.00**	**$8.00**

Totals may not add due to rounding.

[1] Outyear funding estimates are for planning purposes only and do not include ATST operations. The current cooperative agreements ends in FY 2014.

Partnerships and Other Funding Sources: The managing organization for NSO is the Association of Universities for Research in Astronomy, Inc., (AURA), which is comprised of thirty-nine U.S. member institutions and seven international affiliate members. NSO partners include the U.S. Air Force Office of Scientific Research, U.S. Air Force Weather Agency, NASA, and industrial entities. Other funding entities include universities and institutes, which collaborate with NSO on solar instrumentation development and on the design and development of ATST. New telescopes, instrumentation, and sensor techniques are developed through industry sub-awardees in aerospace, optical fabrication, and information technology. Observing time on NSO telescopes is assigned on the basis of merit-based review, not funding source.

Education and Public Outreach: 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 Research Experiences for Undergraduate students (REU) program. NSO has diverse education programs, including teacher training and curriculum development, visitor centers, and a web-based information portal at www.nso.edu.

NSO-Operations, $6.70 million: NSO Operations include facility operations at Sacramento Peak Observatory (SPO) in New Mexico, the world-wide Global Oscillations Network Group (GONG), and solar facilities based on Kitt Peak, Arizona. ATST will replace several of the NSO telescopes at SPO and on Kitt Peak.

NSO-Development, $1.0 million: NSO development funding reported here includes only work apart from ATST, notably for the synoptic program consisting of the GONG array and the SOLIS (Synoptic Optical Long-term Investigations of the Sun) telescope. ATST construction is funded through the Major Research Equipment and Facilities Construction (MREFC) account. (See the ATST narrative in the MREFC chapter for more information).

NSO-Research & Education, $300,000: NSO supports public education in solar physics through its education and public outreach office at SPO. This office provides science community outreach, a visitors' center, news and public information, and activities on Maui in collaboration with University of Hawaii Maui Campus.

Management and Oversight

- NSF Structure: An NSF program director in AST provides continuing oversight, including consultation with an annual NSF program review panel. The program director 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 manager works closely with other offices at NSF, particularly the Division of Acquisition and Cooperative Support, the Office of General Counsel, and the Large Facilities Office in the Office of Budget, Finance, and Award Management.
- External Structure: AURA is the managing organization for NSO. The NSO Director reports to the president of AURA, who is the principal investigator on the FY 2010 NSF cooperative agreement. AURA receives management advice from its Solar Observatory Council, composed of members of its scientific and management communities. NSO employs visiting and users' committees for the purposes of self-evaluation and prioritization. The visiting committee, composed of nationally prominent individuals in science, management, and broadening participation, reviews for AURA all aspects of the management and operations of NSO. The users committee, composed of scientists with considerable experience with the observatory, reviews for the NSO Director all aspects of NSO that affect user experiences at the observatory.

- Reviews: In addition to reviews held mid-way through all cooperative agreements, NSF conducts both periodic and ad hoc reviews of AURA management, as needed, by external committees. The last extensive review for NSO was in FY 2008, and led to the award of a new cooperative agreement at the beginning of FY 2010. Annual reviews are anticipated for both NSO program plans beginning in early 2013. A Business Systems Review is scheduled for spring 2013. A re-baseline review for the ATST project, described in the ATST narrative, was held in October 2012 and a follow-up review will occur in early 2013.

Renewal/Recompetition/Termination

A management review of AURA's performance was carried out in August 2006. In response to the favorable review, the National Science Board extended the existing cooperative agreement with AURA for eighteen months, through September 30, 2009. A proposal for renewal of the cooperative agreement was received from AURA in December 2007 and underwent review in 2008. The National Science Board authorized a new cooperative agreement with AURA for management and operation of NSO for the period October 1, 2009, through March 31, 2014. Since NSO is the home for the ATST construction project, and ATST is not expected to begin operation until 2019, the current cooperative agreement will likely be extended beyond its current expiration in 2014.

NATIONAL SUPERCONDUCTING CYCLOTRON LABORATORY $22,500,000
+$1,000,000 / 4.7%

National Superconducting Cyclotron Laboratory
(Dollars in Millions)

FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request	Change over FY 2012 Enacted Amount	Percent
$21.50	$21.50	$22.50	$1.00	4.7%

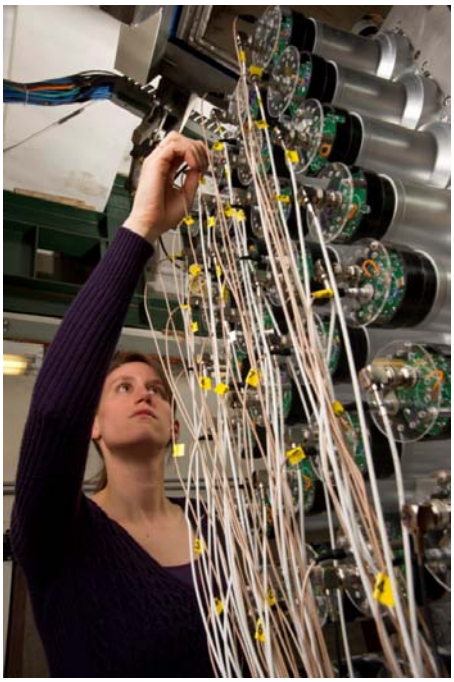
The National Superconducting Cyclotron Laboratory (NSCL) at Michigan State University (MSU) is a university-based national user facility. With two linked superconducting cyclotrons, K500 and K1200, it is the leading rare isotope research facility in the U.S. and is among the world leaders in heavy ion nuclear physics and nuclear physics with radioactive beams. Funding for NSCL also supports the MSU faculty and staff research program.

NSCL scientists employ a range of tools for conducting advanced research in fundamental nuclear science, nuclear astrophysics, and accelerator physics. Applications of the research conducted at the NSCL benefit society in numerous areas, including new tools for radiation treatments of cancer patients and the assessment of health risks to astronauts. 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 is completing construction and commissioning of an MSU-funded reaccelerator facility (ReA3) that will enable experiments at very low energies – a domain of particular interest to nuclear astrophysics.

Scientists at NSCL work at the forefront of rare isotope research. They make and study atomic nuclei that cannot be found on Earth and perform experimental research using beams of unstable isotopes to extend our knowledge of new types of nuclei, many of which are important to an understanding of stellar processes. Research activities include a broad program in nuclear astrophysics studies, the studies of nuclei far from stability using radioactive ion beams, and studies of the nuclear equation of state. In addition, research is carried out in accelerator physics.

NSCL supports and enhances doctorate graduate education and post-doctoral research experiences. About 10 percent of all doctorates granted in nuclear physics in the U.S. are based on research at NSCL. The lab also provides research experiences for undergraduate students, K-12 students, and K-12 teachers.

The coupled cyclotron facility supports a broad experimental program. The mix of experiments is determined by beam use proposals. An external program advisory committee selects the best proposals at a typical success rate of about 50 percent. The science output of NSCL is driven by these experiments, with most running one to three days.



MSU graduate student Krista Meierbachtol working on the S800 CsI Hodoscope, part of the focal plane detector of the S800 magnetic spectrograph. *Credit: NSCL*

Total Obligations for NSCL

(Dollars in Millions)

	FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request	ESTIMATES[1] FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Operations and Maintenance	$21.50	$21.50	$22.50	$22.50	$22.50	$20.00	$15.00	$10.00

[1]Outyear funding estimates are for planning purposes only. The current cooperative agreement ends in FY 2016.

Management and Oversight

- NSF Structure: MSU operates NSCL under a cooperative agreement with NSF. NSF oversight is provided through annual site visits by the cognizant program officer of the NSF Division of Physics and other staff, accompanied by external experts.
- External Structure: NSCL is managed by its director and four associate directors for research, education, operations, and new initiatives. The laboratory director has the authority to appoint associate directors and designate responsibilities, notifying NSF of changes. NSCL's research program is guided by a program advisory committee of external experts as well as an in-house expert, and includes the chairperson of the full NSCL user group. The procedure for users includes writing and submitting proposals to the NSCL director and oral presentations. There are two proposal submission opportunities each year. About 4,000 beam hours are provided for experiments annually, with a backlog of at least a year.
- Reviews:
  - A 5-year review in FY 2011 covered results and achievements related to intellectual merit and broader impacts for the past five years (FY 2007 – FY 2011) and future funding for the next five years (FY 2012 – FY 2016).
  - Latest Review: An annual review of the science, operations, and future funding was in July 2012.
  - Next Review: An annual review is planned for June 2013.

Renewal/Recompetition/Termination

In December 2008 the Department of Energy (DOE) announced that it had selected Michigan State University as the site for a new world-class Facility for Rare Isotope Beams (FRIB). FRIB will be built on the site of the present NSCL and will make use of much of the NSCL beamlines and general infrastructure. Michigan State University will be the performing institution under a cooperative agreement with DOE for the future FRIB. The first FRIB cooperative agreement between DOE and MSU was signed in 2009. To facilitate interagency planning and allow for a smooth transition from the NSF-funded NSCL to the DOE-funded FRIB, a Joint Oversight Group (JOG) of DOE and NSF personnel has been established. NSF anticipates eventually phasing out funding for operations and maintenance for the NSCL facility, as indicated in the table above for FY 2017 through FY 2019. DOE and NSF will coordinate transfer of stewardship of the facility from NSCL to FRIB, which relies on the existing NSCL infrastructure. This responsibility will be assumed by the DOE. NSF will continue to fund individual investigators carrying out research at the new FRIB.

NETWORK FOR EARTHQUAKE ENGINEERING SIMULATION $22,000,000
+$1,500,000 / 7.3%

Network for Earthquake Engineering Simulation

(Dollars in Millions)

FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request	Change over FY 2012 Enacted Amount	Change over FY 2012 Enacted Percent
$20.39	$20.50	$22.00	$1.50	7.3%

The Network for Earthquake Engineering Simulation (NEES) is a national, networked simulation resource of 14 advanced, geographically distributed, multi-user earthquake engineering research experimental facilities with telepresence capabilities. NEES provides a national infrastructure to advance earthquake engineering research and education through collaborative and integrated experimentation, computation, theory, databases, and model-based simulation to improve the seismic design and performance of U.S. civil infrastructure systems. Experimental facilities include shake tables, geotechnical centrifuges, a tsunami wave basin, large-scale laboratory experimentation systems, and mobile and permanently installed field equipment. NEES facilities are located at academic institutions (or at off-campus field sites) throughout the United States, networked together through a high performance Internet2 cyberinfrastructure system (NEEShub). NEES completed construction on September 30, 2004, and opened for user research and education projects on October 1, 2004. NEES was operated during FY 2005-FY 2009 by NEES Consortium, Inc., located in Davis, CA. During FY 2008 and FY 2009, NSF recompeted NEES operations using program solicitation NSF 08-574, George E. Brown, Jr. Network for Earthquake Engineering Simulation Operations (NEES Ops) FY 2010-FY 2014. The outcome of that competition was an award to Purdue University for a five-year cooperative agreement with NSF to operate NEES from FY 2010-FY 2014. Purdue University operates the NEES experimental facilities and cyberinfrastructure; coordinates education, outreach, and training; and develops national and international partnerships.

Total Obligations for NEES

(Dollars in Millions)

	FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request	ESTIMATES[1] FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Operations and Maintenance	$20.39	$20.50	$22.00	$12.00	$13.00	$12.50	$12.50	$12.00

[1] Outyear funding estimates are for planning purposes only. FY 2014 is the final year of the current cooperative agreement. Funding beyond FY 2014 assumes continued operation of the facility as a second generation NEES, as described in the Renewal/Recompetion/Termination section of this narrative.

NEES' broad-based national research facilities and cyberinfrastructure enable new discovery and knowledge through capabilities to test more comprehensive, complete, and accurate models of how civil infrastructure systems respond to earthquake loading and tsunamis. This enables the design of new methodologies, modeling techniques, and technologies for earthquake and tsunami hazard mitigation. NEES engages students in earthquake engineering discovery through on-site use of experimental facilities, telepresence technology, archival experimental and analytical data, and computational resources

with the aim of integrating research and education. Purdue University operates NEES under a strategic plan and develops a broad spectrum of education and human resource development activities with special emphasis on non-traditional users and underrepresented groups through its Research Experiences for Undergraduates (REU) program. Purdue also organizes an annual meeting for NEES users/researchers and facility operators.

Using a unique landslide tsunami generator, researchers at the Georgia Institute of Technology in cooperation with faculty at University of Alaska at Fairbanks are investigating a methodology for improved assessment and mitigation of landslide and tsunami hazards. Field data from landslide-generated tsunamis events are limited to very few cases with marginal data that are generally missing the most important information related to tsunami generation characteristics. Researchers are compensating for this lack of field data by creating physical models of three-dimensional tsunami generation by deformable landslides and source run-up in the NEES Tsunami Wave Basin at Oregon State University. *Credit: Devin K. Daniel, California Polytechnic State University, San Luis Obispo, NEES summer 2010 REU student*

Through the National Earthquake Hazards Reduction Program (NEHRP), which includes the Federal Emergency Management Agency (FEMA), the National Institute of Standards and Technology (NIST) as the lead agency, the U.S. Geological Survey (USGS), and NSF, NEES supports research and outreach related to earthquake hazard mitigation. Connections to industry include private engineering consultants and engineering firms engaging in NEES research or using data and models developed through NEES. NEES leverages and complements its capabilities through connections and collaborations with large testing facilities at foreign earthquake-related centers, laboratories, and institutions. NSF has developed a partnership to utilize the NEES infrastructure with the 3-D Full-Scale Earthquake Testing Shake Table Facility (E-Defense), located in Miki City, Japan, and built by the Japanese National Research Institute for Earth Science and Disaster Prevention (NIED), which became operational in 2005. To facilitate NEES/E-Defense collaboration, in September 2005 NSF and the Japanese Ministry of Education, Culture, Sports, Science, and Technology signed a Memorandum Concerning Cooperation in the Area of Disaster Prevention Research. In August 2011, two NSF-supported research projects used a full-scale, five-story steel frame structure at the E-Defense facility to test new seismic base isolation concepts and the response of non-structural systems during strong seismic motion, and in 2012 an NSF-supported research project participated in large-scale experiments at the E-Defense facility to investigate soil-structure interaction of underground structures.

Along with direct operations and maintenance support for NEES, NSF separately provides support for research to be conducted at the NEES experimental facilities through ongoing research and education programs. The NEEShub also provides a platform for the earthquake engineering and tsunami communities, as well as other communities, to develop new tools for shared cyberinfrastructure. The annual support for such activities, funded through annual NEES research program solicitations, is estimated to be up to $9.0 million in FY 2013. These awards support basic research in multi-hazard engineering involving experimental and computational simulations at the NEES facilities, addressing important challenges in earthquake and tsunami engineering research. ENG support for NEES Operations will continue to support core research conducted at the 14 network sites through FY 2014.

Management and Oversight

- NSF structure: NSF provides oversight to NEES operations through a cooperative agreement with Purdue University during FY 2010-FY 2014. NEES operations are reviewed through annual site visits and through periodic site visits to the individual NEES facilities. The annual site reviews are held at either the headquarters or at NSF. All reviews involve an external team of experts selected by

NSF staff. The NSF program manager for NEES is located in the Division of Civil, Mechanical and Manufacturing Innovation (CMMI) in the Directorate for Engineering (ENG). The Deputy Director for Large Facility Projects in the Office of Budget, Finance and Award Management (BFA) provides advice and assistance.

- External structure: Purdue University provides the headquarters and staffing to coordinate network-wide operation of the NEES experimental facilities, cyberinfrastructure, and education, outreach, and training activities as well as develop national and international partnerships. Day-to-day operations of the network are overseen by the headquarters staff led by a director. A governance board meets several times a year and provides independent advice and guidance to the director concerning the network's programs, activities, vision, funding allocations, and new directions. The governance board shares its major recommendations with NSF. Each of the 14 experimental facilities has an on-site director responsible for local day-to-day equipment management, operations, and interface with Purdue, other NEES facilities, users, and the NEEShub for network coordination. The NEEShub provides telepresence, the NEES Project Warehouse data repository, and collaborative, simulation, and other related services for the entire NEES network.

- Reviews
  - Management reviews: NSF BFA Business Systems Review: May 2006
  - Mid-award operations reviews: NSF Annual Merit Reviews: June 2005, April 2006, July 2007
  - Experimental facility reviews: NSF Periodic Merit Reviews: FY 2006-FY 2008
  - Transition review: April 2010
  - Management reviews: NSF BFA Business Systems Review: March 2011
  - Mid-award operations reviews: NSF Annual Merit Reviews: FY 2010-FY 2013
  - Experimental facility reviews: Up to three annually: FY 2010-FY 2013

Renewal/Recompetition/Termination

In FY 2008, NSF recompeted NEES operations for a second five-year period from FY 2010-FY 2014. The competition was announced in program solicitation NSF 08-574, George E. Brown, Jr. Network for Earthquake Engineering Simulation Operations (NEES Ops) FY 2010-FY 2014. As an outcome of that competition, the National Science Board, at its August 5-6, 2009 meeting, approved NSF's recommendation for a five-year cooperative agreement (FY 2010-FY 2014) to Purdue University. Annual funding to Purdue University for NEES operations is based upon satisfactory progress and availability of funding. During FY 2010, the prior NEES operations awardee, NEES Consortium, Inc., was supported by NSF to provide continuity of operations and to help transition software, documents, and other inventory to Purdue University. During FY 2010, NEES Consortium, Inc., also closed out its support for NEES operations.

In FY 2010, NSF supported two studies for the assessment of the need for earthquake engineering experimental and cyberinfrastructure facilities beyond 2014, as described in the Dear Colleague Letter NSF 10-071 (http://nsf.gov/pubs/2010/nsf10071/nsf10071.jsp). 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 2014. The plan to support, as the outcome of an open recompetition to be held during FY 2013-FY 2014, a smaller "second generation" NEES during FY 2015-FY 2019 was presented to the National Science Board at their July 2012 meeting and described in the Dear Colleague Letter NSF 12-107 (www.nsf.gov/pubs/2012/nsf12107/nsf12107.jsp). In February 2013, the Foundation released solicitation NSF 13-537 to re-compete and operate the second generation of NEES (NEES2) for the five-year period from FY 2015 – FY 2019. NSF also will support longer-term community planning for FY 2020 – FY 2029.

POLAR FACILITIES AND LOGISTICS

$314,210,000
+$18,420,000 / 6.2%

Polar Facilities and Logistics
(Dollars in Millions)

	FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request	Change over FY 2012 Enacted Amount	Change over FY 2012 Enacted Percent
Polar Facilities	$185.02	$184.73	$202.69	$17.96	9.7%
Polar Logistics	109.60	111.06	111.52	0.46	0.4%
Total, Polar Facilities and Logistics	**$294.63**	**$295.79**	**$314.21**	**$18.42**	**6.2%**

Totals may not add due to rounding.

Polar Facilities

The Division of Polar Programs (PLR) within the Directorate for Geosciences (GEO) provides the infrastructure needed to support U.S. research conducted in Antarctica, including research funded by U.S. mission agencies, for year-round work at three U.S. stations, on two research ships, and at a variety of remote field camps. One example of support to other agencies includes mission-essential satellite communications support at McMurdo Station for the Joint Polar Satellite System (JPSS) and the National Aeronautics and Space Administration's (NASA) Ground Networks for the relay of data. In addition, PLR enables important climate monitoring activities for the National Oceanic and Atmospheric Administration (NOAA) at the Clean Air Facility at South Pole Station, one of only five such sites around the globe. PLR also provides support for NASA's Long Duration Balloon program that enables research in fields ranging from astrophysics to cosmic radiation to solar astronomy. PLR also provides support to the U.S. Geological Survey's (USGS) South Pole Remote Earth Science and Seismological Observatory (SPRESSO), the most seismically-quiet station on earth, and access to its Global Navigation Satellite System (GNSS).

All support for these activities is provided by PLR, including transportation, facilities, communications, utilities (water and power), health and safety infrastructure, and environmental stewardship. The U.S. Antarctic Program (USAP) maintains the U.S. presence in Antarctica in accordance with U.S. policy, and supports Antarctic Treaty administration under State Department leadership.

Total Obligations for Polar Facilities
(Dollars in Millions)

	FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request	ESTIMATES[1] FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Antarctic Infrastructure & Logistics	$185.02	$184.73	$202.69	$202.69	$202.69	$202.69	$202.69	$202.69
Total, Polar Facilities	**$185.02**	**$184.73**	**$202.69**	**$202.69**	**$202.69**	**$202.69**	**$202.69**	**$202.69**

Totals may not add due to rounding.

[1] Outyear funding estimates are for planning purposes only.

PLR contracts with a prime contractor for science support, operations, the leasing of research vessels, and

the maintenance of the Antarctic stations and related infrastructure in New Zealand and Chile. The contractor is selected through a competitive process. Rotary- and fixed-wing aircraft used in support of research are also provided through separate competitively awarded contracts. Other agencies and contractors provide technical support in areas of expertise such as engineering, construction, and communications.

Management and Oversight

- NSF Structure: PLR staff including, subject matter experts in operational and scientific disciplines, have overall responsibility for funding and managing Polar Facilities under the U.S. Antarctic Program that NSF budgets for and manages on behalf of the Nation. This includes planning all activities, and overseeing contractors. PLR's Antarctic Sciences Section funds merit-reviewed research proposals for which access to Antarctica is essential to advancing the scientific frontiers, including research in a broad array of geo- and bio- sciences, including earth system science, as well as space and astrophysical sciences that can only be achieved or are best achieved with research work in Antarctica and the Southern Ocean. The Antarctic Infrastructure & Logistics Section enables research in Antarctica on behalf of the U.S. Government through a network of stations, labs, equipment, and logistical resources. The Environment, Safety & Health Section oversees the environmental, safety, and health aspects of research and operations conducted in Polar Regions.

Helicopters provide support to field parties in the McMurdo Dry Valleys in southern Victoria Land and at remote field camps. *Credit: Kristan Hutchison, RPSC*

- External Structure: The Antarctic support contract was competed and awarded to Lockheed Martin Corporation in December 2011. There are many separate subcontractors for supplies and technical services, and other services are procured through separate competitively bid contracts.
- Reviews: PLR evaluates the performance of the Antarctic support contractor annually via an Award Fee Plan, which involves multiple tiers of review, including a Performance Evaluation Board (PEB) composed of representatives from PLR and the Office of Budget, Finance, and Award Management (BFA). In addition, PLR's performance is reviewed externally by Committees of Visitors and the GEO Advisory Committee. The USAP Blue Ribbon Panel (BRP) released a report on its review of the Program in July 2012. [4] The NSF Response to the USAP Blue Ribbon Panel report was released in March 2013.[5]

Current Status

- All facilities (stations, research vessels, and field camps), including the recently-constructed South Pole Station, are currently operating normally.
- South Pole Station Modernization (SPSM) was funded through NSF's Major Research Equipment and Facilities Construction (MREFC) account. The new station was dedicated in January 2008 and construction was completed in January 2011. The new station replaced the previous U.S. station at the South Pole, built 30 years ago and inadequate in terms of capacity, efficiency, and safety. The new station is an elevated complex with two connected buildings, supporting 150 people in the summer and 50 people in the winter. The completed station provides a platform for the conduct of science at the South Pole and fulfills NSF's mandate to maintain a continuous U.S. presence at the South Pole in accordance with U.S. policy. Operations and maintenance of South Pole Station is consolidated within the requested budget for polar facilities.

[4] www.nsf.gov/od/opp/usap_special_review/usap_brp/rpt/index.jsp
[5] www.nsf.gov/od/opp/usap_special_review/usap_brp/rpt/nsf_brp_response.pdf

- 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, they 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. NSF's response to the report, released in March 2013, responds directly to the ten overarching recommendations made by the BRP and includes information on planned improvements over the near- and long-term, such as roboticizing the South Pole traverse, improving boating access at Palmer Station, conducting a study to improve fire suppression capabilities, and initiating design work to consolidate warehousing facilities at McMurdo Station. For additional information on planned BRP response activities during FY 2014, see the Division of Polar Programs (PLR) narrative in the Directorate for Geosciences chapter.

Renewal/Recompetition/Termination

- NSF recently concluded an effort to recompete the Antarctic support contract. 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 and totaling an additional 8.5 years.
- 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. The research emphases at the three stations change as the scientific forefronts addressed there evolve with time, as does the infrastructure needed to support it.

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 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request	ESTIMATES[1] FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
U.S. Antarctic Logistical Support	$67.52	$67.52	$67.52	$67.52	$67.52	$67.52	$67.52	$67.52
Arctic Research Support and Logistics	42.08	43.54	44.00	44.00	44.00	44.00	44.00	44.00
Total, Polar Logistics	**$109.60**	**$111.06**	**$111.52**	**$111.52**	**$111.52**	**$111.52**	**$111.52**	**$111.52**

Totals may not add due to rounding.

[1] Outyear funding estimates are for planning purposes only.

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 U.S. Antarctic Program; support for air traffic control, weather forecasting, and ground electronics maintenance; the charter of Air Mobility Command airlift and Military Sealift Command ships for the re-supply of McMurdo Station;

bulk fuel purchased from the Defense Logistics Agency; and reimbursement for use of DoD satellites for communications.

The Research Support and Logistics program in the Arctic Sciences Section of PLR is driven by and 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 U.S. Coast Guard and other icebreakers, University-National Oceanographic Laboratory (UNOLS) vessels and coastal boats; access to fixed- and rotary-wing airlift support; upgrades at Toolik Field Station, University of Alaska Fairbanks' field station for ecological research on Alaska's North Slope; safety training for field researchers and funding for field safety experts; global satellite telephones for emergency response and improved logistics coordination; and development of a network of strategically placed U.S. observatories linked to similar efforts in Europe and Canada.

Management and Oversight

- NSF Structure: PLR has overall responsibility for U.S. Antarctic Logistical Support and Arctic Research Support & Logistics.
  - U.S. Antarctic Logistical Support is budgeted for and managed by the Antarctic Infrastructure and Logistics Section, which includes managers with operational expertise responsible for planning and overseeing all U.S. Antarctic Program 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 is driven by and responds to research by assisting researchers with access to the Arctic and sharing of plans and results with local Arctic communities. The Environment, Safety & Health Section oversees the environmental, safety, and health 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 recently re-competed and awarded to the incumbent, CH2M Hill, in September 2011. There are many separate subcontractors for supplies and technical services, and other services are procured through separate competitively bid contracts.
- Reviews: PLR evaluates the performance of the Arctic support contractor informally on an ongoing basis and formally each year using feedback from the research community they support, and by conducting site visits that include representatives from PLR and BFA. PLR's performance is externally reviewed by Committees of Visitors and the GEO Advisory Committee.

Current Status

- All facilities (stations, research vessels, and field camps) are currently operating as normal.

Renewal/Recompetition/Termination

- NSF recently recompeted the Arctic support contract and made an award to the incumbent contractor, CH2M Hill, in September 2011. The contract has an initial term of four years and the possibility of two, two-year extensions exercised on the basis of performance.

SEISMOLOGICAL FACILITIES FOR THE ADVANCEMENT OF GEOSCIENCE AND EARTHSCOPE **$25,700,000**
-$1,060,000 / -4.0%

Seismological Facilities for the Advancement of Geoscience and EarthScope

(Dollars in Millions)

FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request	Change over FY 2012 Enacted Amount	Change over FY 2012 Enacted Percent
$26.12	$26.76	$25.70	-$1.06	-4.0%

The Seismological Facilities for the Advancement of Geoscience and EarthScope (SAGE) comprise a distributed, multi-user, national facility for the development, deployment, and operational support of modern digital seismic instrumentation to serve national goals in basic research and education in the Earth sciences, earthquake research, global real-time earthquake monitoring, and nuclear test ban verification. SAGE is managed and operated for NSF by the Incorporated Research Institutions for Seismology (IRIS), a consortium of 116 U.S. universities and non-profit institutions with research and teaching programs in seismology, 21 educational affiliates, and 116 foreign affiliates. SAGE will be formed in late FY 2013 from part of the EarthScope program and the IRIS facility. FY 2012 and FY 2013 funding shown in all tables presented here have been restated for comparative purposes.

Total Obligations for SAGE

(Dollars in Millions)

	FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request	ESTIMATES[1] FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Operations and Maintenance	$26.12	$26.76	$25.70	$25.70	$25.70	$25.70	$25.70	$25.70

[1] Outyear funding estimates are for planning purposes only. The new cooperative agreement begins in FY 2013.

The Earth's interior remains a major scientific frontier holding the key to understanding the origin of the planet. Recent developments in seismic sensor design, and the acquisition, transmission, and storage of data have resulted in dramatic improvements in the resolving power of seismic imaging of the interior. To serve the research needs of the broad Earth science community, SAGE is organized under three primary Service Areas and two Special Emphasis Areas:

- **Instrumentation Services**
  - The Global Seismographic Network (GSN) consists of over 150 permanently installed broadband digital seismic stations, most of which have real-time data access.
  - Portable Seismology (PS) includes a pool of over 5,200 portable seismometers that are made available to the Earth science research community for a wide range of principal investigator-driven experiments largely funded through the NSF merit review process, and incorporates equipment from the former Program for Array Seismic Studies of the Continental Lithosphere (PASSCAL) and EarthScope USArray/Flexible Array (FA) activities.
  - Polar Support Services (PSS) supports the development of specialized seismic equipment for use in harsh environments and provides instrumentation, training, and field support for experiments in

the Polar regions. Additional supplemental funding for these activities is provided through the Division of Polar Programs (PLR).

- The Transportable Array (TA) is a continental-scale seismic observatory designed to provide a foundation for integrated studies of continental lithosphere and deep Earth structure over a wide range of scales. TA incorporates over 400 stations across the lower 48 states and Alaska.
- The Magnetotelluric (MT) component exploits the natural variations in Earth's magnetic and electric fields to provide information on the distribution and composition of fluids in Earth's crust and upper mantle, which gives constraints on Earth's structure that are complementary to those resulting from seismology. MT comprises seven long-term, continuously operating backbone stations and 21 transportable instruments used for short-term deployments.
- Instrumentation Services-Coordinated Activities, include future-focused 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 200 terabytes of seismic, magnetotelluric, and other data from all SAGE components, the EarthScope program, and numerous affiliated networks; operates automated and manual systems to ensure the quality of all data stored in the archive; and provides systems to give the national and international research community with timely access to these data.

- **Education and Public Outreach**
  - The SAGE Education and Public Outreach (EPO) Program enables audiences beyond seismologists to access and use seismological data and research, including student internships, and programs for under-resourced educational institutions.

- **Special Emphasis Areas**
  - Community Activities include scientific and technical workshops that bring together the international seismic community and publications designed to communicate SAGE activities and results to the community.
  - International Development Seismology (IDS) leverages the core SAGE Service Areas to provide capacity building and training for earthquake hazard mitigation in developing countries, through technical assistance and research collaborations with scientists at U.S. academic institutions.

A student volunteer prepares to deploy a sensor on a wind farm near Palm Springs, California, that will record high-frequency seismic waves for the Salton Sea Imaging Project. Principal Investigators: John Hole, Virginia Tech, Joann Stock, Caltech, and Gary Fuis, USGS. *Credit: IRIS.*

Besides its role in providing the observational data essential for basic Earth science research, SAGE also plays a significant role providing real-time seismic data to the U.S. Geological Survey (USGS) and the National Oceanic and Atmospheric Administration (NOAA) for global earthquake, volcano, and tsunami monitoring; international seismic monitoring of compliance with the Comprehensive Test Ban Treaty; and bringing seismology to students and the public through the activities of its EPO program.

SAGE is heavily involved in partnership activities, many international in nature. Installation and operation of the GSN has put IRIS in contact with scientists, as well as government and non-government organizations, from around the world. Many international GSN stations are designated as the official stations for nuclear test ban monitoring in their host countries. SAGE also provides multi-use resources for other government agencies that have responsibilities for

development of a nuclear test ban monitoring capability and for monitoring global seismicity. For these purposes, agencies in partnership with NSF have provided substantial support for accelerated development of the GSN, shared operation and maintenance of the GSN, and accelerated development of the Portable Seismology instrument pool.

The use for investigations of the shallow crust by instruments made available through SAGE Portable Seismology component provides opportunities for collaboration with the petroleum exploration industry. Many students involved in these experiments receive training in techniques that prepare them for careers in the exploration industry. In a broader sense, IRIS continues to collaborate closely with industry in development of seismic instrumentation and software.

The EarthScope, Geophysics, GeoPRISMS, and Tectonics Programs in the Division of Earth Sciences (EAR); the GeoPRISMS and Marine Geology and Geophysics Programs in the Division of Ocean Sciences (OCE); and the Geology and Geophysics Program and the Glaciology Program in the Antarctic Research Section of the Division of Polar Programs (PLR) provide most of the funds, totaling approximately $15.0 million per year, for NSF-sponsored research making use of SAGE. Funds permit deployment of portable seismic instruments and use of data managed by Data Services to solve major Earth science problems.

Management and Oversight

- NSF Structure: EAR, through its Instrumentation & Facilities Program (IF), provides general oversight of SAGE to help assure effective performance and administration. The program also facilitates coordination of SAGE programs and projects with other NSF-supported facilities, and with other federal agencies, and evaluates and reviews the performance of IRIS in managing and operating SAGE.
- External Structure: SAGE is managed and operated by IRIS, which is incorporated as a non-profit consortium representing 116 U.S. universities and non-profit organizations with research and teaching programs in seismology. Each voting Member Institution of the Consortium appoints a Member Representative, and these Member Representatives elect the nine members of the IRIS Board of Directors. The Board members, who serve three-year terms, vet all internal program decisions associated with SAGE management and operation, through consultation with IRIS staff and SAGE advisory committees (one for each major SAGE component and additional *ad hoc* working groups appointed for special tasks). The Board of Directors appoints a president of IRIS to a renewable two-year term. The president is responsible for IRIS operations, all of which are managed through the IRIS Corporate Office located in Washington, DC.
- Reviews: All major ongoing geoscience facilities routinely undergo mid-award reviews of their management, in addition to peer review of proposals for new or continued support. The formal NSF merit review of the 5-year proposal for the SAGE facility took place in 2012 and 2013 and was also the most recent review of IRIS. Although the *ad hoc* reviewers and two independent review panels had a number of specific recommendations at the working level for SAGE, overall the review found that SAGE was a critical facility for U.S. and international Earth sciences. Furthermore, the reviewers found that IRIS is a well-managed and effective organization that has, through its commitment to the collection and open dissemination of the highest quality seismological data, transformed the discipline of seismology. A review of the IRIS Data Services also took place during 2012. The review panel was impressed by the level of service provided to the research community by the Data Services Program, and made specific recommendations to IRIS and to NSF to further enhance the services provided by this component of the facility.

Renewal/Recompetition/Termination

The initial cooperative agreement for SAGE begins in FY 2013. In FY 2017, in keeping with the phased integration and recompetition plan presented to and concurred with by the National Science Board (NSB)

in December 2009, NSF intends to solicit proposals for a future facility or facilities to support the Earth sciences research and education community currently supported by SAGE and the related Geodetic Facilities for the Advancement of Geoscience and EarthScope (GAGE). NSF is currently considering the precise form of this solicitation, and any possible future facility/facilities are currently being considered within NSF and through discussions with the SAGE and GAGE support communities.

FEDERALLY FUNDED RESEARCH AND DEVELOPMENT CENTERS (FFRDCs)

NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

$99,000,000
+$400,000/ 0.4%

National Center for Atmospheric Research
(Dollars in Millions)

FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request	Change over FY 2012 Enacted Amount	Change over FY 2012 Enacted Percent
$103.00	$98.60	$99.00	$0.40	0.4%

The Mesa Laboratory, designed by architect I.M. Pei, in Boulder, CO. *Credit: NCAR.*

The National Center for Atmospheric Research (NCAR) is a Federally Funded Research and Development Center (FFRDC) serving a broad research community, including atmospheric scientists and researchers in complementary areas of the environmental and geosciences. NCAR is managed under a cooperative agreement with NSF by the University Corporation for Atmospheric Research (UCAR), a university-governed and university-serving organization comprising 78 Ph.D. granting academic institutions.

As of November 2012, NCAR supported a total of 824.5 full time equivalents (FTEs), of which 360.6 are funded under the NSF primary award to UCAR.

Number of FTEs Supported at NCAR

FTEs	Primary Award[1]	All Funding
Career Scientists	84.8	116.7
Scientific Support[2]	258.8	576.6
Other Staff[3]	17.0	131.2
Total	**360.6**	**824.5**

[1] The primary award supports substantial facility infrastructure that does not include staff costs.

[2] Scientific Support includes Associate Scientists, Project Scientists, Post Docs, Software Engineers, Engineers, System Support and Technicians.

[3] Other Staff includes Administrative positions, Managers, Paid Visitors, Pilots and Mechanics.

NCAR provides facilities, including world-class supercomputing services, research aircraft, airborne and portable ground-based radar systems, atmospheric sounding, and other surface sensing systems for atmospheric research, to university, NCAR, and other atmospheric researchers. In addition, NCAR operates several facilities dedicated to the study of the Sun, solar phenomena, space weather, and the responses of the upper atmosphere to the Sun's output.

Total Obligations for NCAR

(Dollars in Millions)

	FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request	ESTIMATES[1] FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Aircraft Support	$10.00	$9.50	$9.50	$9.50	$9.50	$9.50	$9.50	$9.50
Computational Infrastructure	25.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00
Other Facility Support	25.00	21.10	21.50	21.50	21.50	21.50	21.50	21.50
Research & Education Support	43.00	41.00	41.00	41.00	41.00	41.00	41.00	41.00
Total, NCAR	**$103.00**	**$98.60**	**$99.00**	**$99.00**	**$99.00**	**$99.00**	**$99.00**	**$99.00**

Totals may not add due to rounding.

[1] Outyear funding estimates are for planning purposes only.

Partnerships and Other Funding Sources: NCAR leverages NSF support with funding provided by other federal agencies and non-federal sources. In FY 2012, NCAR received approximately $38.90 million in support from other federal agencies, such as the National Oceanographic and Atmospheric Administration (NOAA) and the Federal Aviation Administration (FAA), and $18.0 million from non-federal sources.

Major Investments in FY 2014: In FY 2014, investments at NCAR will focus on issues of societal importance in the areas of atmospheric chemistry, climate, including climate models, cloud physics, severe storms, weather hazards to aviation, and interactions between the Sun and Earth. In all of these areas, NCAR scientists will work with their university colleagues to look closely at the role of humans in both creating climate change, responding to severe weather occurrences, and to better understand the characteristics of the Sun and Sun-Earth connections. Example investments are an increased emphasis on preparing input for the next Intergovernmental Panel on Climate Change (IPCC) assessment in FY 2014 and research into significantly enhancing our ability to understand and predict changes in hurricane intensity.

Aircraft Support: NCAR operates a C-130 and a Gulfstream-V (G-V, also known as the High Altitude Instrumented Airborne Platform for Experimental Research, or HIAPER), both of which are highly modified and equipped with specialized instrumentation, to enable the support of research activities designed to understand complex environmental processes. The two aircraft will support several community-originated projects deemed by peer review to be of exceptional scientific merit.

Computational Infrastructure: NCAR's computational facility supports high-end modeling and simulation of climate, weather, and other Earth Systems processes. Additionally, this facility supports the development and application of the Interagency United States Global Change Research Program (USGCRP) Community Earth System Model (CESM), which uses mathematical formulas to simulate and better understand the chemical and physical processes that drive Earth's climate system.

NCAR completed construction of the NCAR-Wyoming Supercomputing Center (NWSC) in early 2012, which is a joint effort between NCAR and the University of Wyoming and other Wyoming partners. This new facility, along with the installation of the petascale *Yellowstone* Supercomputer in late 2012, provides the physical infrastructure and computational capability to better meet the high-end computational needs of the atmospheric and related sciences and to allow the development of supercomputing research and educational activities of specific interest to the University of Wyoming and the state.

Other Facility Support: In addition to the C-130 and G-V aircraft, NCAR also provides support for a number of other atmospheric observing platforms through its Earth Observing Laboratory (EOL),

including a large transportable Doppler radar, upper atmosphere observing capabilities, and other experimental systems. NCAR operates a coronagraph as a community resource, and supports community weather and climate models, as well as other infrastructure. These facilities are used by both NCAR and community researchers to undertake cutting edge research projects.

Research and Education Support: Total funding for research and education support at NCAR totals $41.0 million in FY 2014. As an internationally recognized center of excellence, NCAR operates scientific research programs that include the following areas:

- studies of large-scale atmospheric and ocean dynamics that contribute to an understanding of the past and present climate processes and global climate change;
- global and regional atmospheric chemistry, including atmospheric connections to geochemical and biogeochemical cycles;
- the variable nature of the sun and the physics of the corona and their interaction with the Earth's magnetic field;
- the physics of clouds, thunderstorms, precipitation formation, and their interactions and effects on local and regional weather; and
- the examination of human society's impact on and response to global environmental change.

Research collaborations among NCAR staff and university colleagues are integral to its success as an institution, and serve as a focus and meeting point for the broader atmospheric and related sciences community. Further, NCAR works to develop new collaborations and partnerships with the private sector through directed research and technology transfer. These activities span improved capabilities for detecting, warning, and forecasting mesoscale weather phenomena of economic and social importance to the private and public sectors to longer-term economic consideration of climate change issues.

Educational activities include the SOARS (Significant Opportunities in Atmospheric Research and Science) program, an undergraduate-to-graduate bridge program designed to broaden participation in the atmospheric and related sciences, which integrates research, education, and mentoring.

In addition, NCAR further supports the scientific community by providing fellowships, internships, workshops, and colloquia for students and visiting scientists, and disseminates knowledge of the geosciences. Professional training courses, innovative and award-winning science education websites[6], as well as the directed activities of NCAR's education and outreach programs are further examples of how NSF's goal of integrating research and education is attained through NCAR activities.

Management and Oversight

- NSF Structure: NSF's Division of Atmospheric and Geospace Sciences (AGS), along with the Division of Acquisitions and Cooperative Support (DACS), provide oversight of NCAR and the cooperative agreement with the University Corporation for Atmospheric Research (UCAR) for NCAR's management. The cooperative agreement between UCAR and NSF encourages interactions between NCAR scientists and AGS staff and ensures close coordination between AGS and NCAR management. The agreement contains requirements necessary for AGS's oversight of the NCAR program and UCAR management activities that affect NCAR. These include a provision that UCAR submit an annual program plan for AGS approval that provides details on how resources will be used in that fiscal year. In addition, NCAR summarizes its past year's accomplishments in an annual scientific report. Annual strategic planning sessions between AGS, UCAR, and NCAR are held to ensure that scientific and facility priorities remain consistent with those of NSF.

[6] www.spark.ucar.edu

- External Structure: UCAR works in partnership with NSF and the university community to ensure the effective implementation of the strategic mission of NCAR to the benefit of the research community. In addition, other research sponsors, such as the National Aeronautics and Space Administration (NASA), NOAA, the Department of Energy (DOE), the Department of Defense (DOD), the Environmental Protection Agency (EPA), and the FAA support research collaboration wherever it enhances NCAR's basic NSF-supported research goals or facilities missions.

- Reviews: A Committee of Visitors (COVs) is conducted every three years; the most recent was FY 2012. A Business Systems Review (BSR) was conducted in FY 2011; the next will take place in FY 2016. No significant issues were raised in either review.

Renewal/Recompetition/Termination

The award to manage NCAR was last re-competed in FY 2007, and the new award began on October 1, 2008. During 2011, AGS conducted a series of six site visits to NCAR, with a total of 38 external reviewers, to examine NCAR's science programs and management. Each site visit team reported that NCAR continues to serve a critical role in the ongoing success of the atmospheric and related sciences communities and that the Center and staff remain at the forefront of their respective fields.

Based on the strong endorsement of reviewers and UCAR's conduct during the award period, AGS informed the National Science Board in May 2012 that UCAR would be permitted to submit a proposal to renew the award for a further five years, after which it would be competed again. UCAR was advised that its proposal should follow the guidance in the 2007 solicitation. The proposal was received in September 2012, and the review process began in October. Final action is anticipated by May 2013.

NATIONAL OPTICAL ASTRONOMY OBSERVATORY

$25,500,000
$0 / 0.0%

National Optical Astronomy Observatory
(Dollars in Millions)

FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request	Change over FY 2012 Enacted Amount	Percent
$26.25	$25.50	$25.50	-	-

Totals may not add due to rounding.

The National Optical Astronomy Observatory (NOAO) was established in 1982 by uniting operations of the Kitt Peak National Observatory (KPNO) in Arizona and the Cerro Tololo Inter-American Observatory (CTIO) in Chile. NOAO is a Federally Funded Research and Development Center (FFRDC) for research in ground-based, nighttime, optical, and infrared (OIR) astronomy. NOAO is the gateway for the U.S. astronomical community to the International Gemini Observatory and to other U.S. OIR telescopes that offer public access. For all of these telescopes, NOAO peer-review telescope allocation committees provide competitive merit-based telescope time allocation, but no financial support. NOAO manages national community involvement in the development of potential future infrastructure projects and is closely involved in the design, development, and potential construction and operations of the Large Synoptic Survey Telescope (LSST). LSST was the highest priority recommendation for "New Ground-Based Activities – Large Projects" of the 2010 Decadal Survey conducted by the National Research Council's Astronomy and Astrophysics Survey Committee, and is requested for an FY 2014 construction start funded through the Major Research Equipment and Facilities Construction (MREFC) account. Presently NOAO is expected to be responsible for the telescope and site during the construction phase of the LSST project.

NOAO telescopes are open to all astronomers regardless of institutional affiliation on the basis of peer-reviewed observing proposals. They serve nearly 1,200 U.S. and foreign scientists annually. In FY 2012, 72 thesis students and an additional 80 non-thesis graduate students from U.S. institutions used NOAO telescopes for their research. In FY 2012 NOAO employed 356 personnel in Arizona and Chile, including 46 support scientists and 13 postdoctoral fellows.

The NSF Division of Astronomical Sciences in the NSF Directorate for Mathematical and Physical Sciences (MPS/AST) carried out a community-based review of its entire portfolio during FY 2012. The recommendations from the Portfolio Review Committee's report included divesting NSF support from three telescopes located on Kitt Peak: the 4-meter Mayall telescope, the 2.1-meter telescope, and the 3.5-meter WIYN (Wisconsin-Indiana-Yale-NOAO) telescope. The first two of these telescopes are fully available (except for closure due to weather or maintenance) for public access. The WIYN telescope is owned and operated by a collaboration among three universities (University of Wisconsin, Indiana University, and Yale University) and NOAO. NOAO's share of the WIYN telescope time for public access is 40 percent. At this time, NSF is considering the Portfolio Review Committee's recommendations, and no decisions have been made. The impact of the Portfolio Review on long-term funding will be presented in future Requests.

Total Obligations for NOAO

(Dollars in Millions)

	FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request	ESTIMATES[1] FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
NOAO-Operations	$20.00	$19.80	$20.00	$21.00	$21.00	$21.00	$21.00	$21.00
NOAO-Development	4.10	3.90	3.40	4.00	4.00	4.00	4.00	4.00
NOAO-Research and Education	0.65	0.60	0.60	0.50	0.50	0.50	0.50	0.50
LSST[2]	1.50	1.20	1.50	-	-	-	-	-
Total, NOAO	**$26.25**	**$25.50**	**$25.50**	**$25.50**	**$25.50**	**$25.50**	**$25.50**	**$25.50**

Totals may not add due to rounding.

[1] Outyear funding estimates are for planning purposes only. The current cooperative agreement ends in FY 2014.

[2] Outyear projections for LSST assume an MREFC construction start late in FY 2014.

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 thirty-nine U.S. member institutions and seven international affiliate members. A key ongoing NOAO partnership has been the preparation of the 4-meter CTIO Blanco telescope for the Dark Energy Survey, which is beginning in early 2013. This survey is a collaboration with the Department of Energy (DOE) to conduct a five-year survey of the southern sky to investigate the nature of dark energy. In addition, DOE has recently issued a "Critical-Decision-0" statement of need for a dark-energy spectroscopic survey on a 4-meter optical telescope; the NOAO Mayall telescope on Kitt Peak and the Blanco telescope on Cerro Tololo both are candidate platforms for such a survey. Along with the WIYN telescope mentioned above, NOAO is a partner in the 4.1-meter SOAR (Southern Astrophysical Research) telescope at CTIO. SOAR partners include the University of North Carolina, Chapel Hill; Michigan State University; and the Ministério da Ciência, Tecnologia, e Inoviçao of Brasil. Finally, in the context of the aforementioned Portfolio Review report, NOAO issued a call for expressions of interest in possible partnerships for funding of its large telescopes on Kitt Peak; the replies to this call are being evaluated by NOAO and NSF.

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. In FY 2012, NOAO received $10.31 million 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 PhD dissertations. The observatories introduce undergraduate students to scientific research by providing stimulating environments for basic astronomical research and related technologies through NSF's Research Experiences for Undergraduate Students (REU) program. NOAO has a diverse education program, visitor centers, and a web-based information portal at www.noao.edu.

NOAO-Operations: $20.0 million: NOAO-Operations support covers the operation of facilities at KPNO, CTIO, and the headquarters, offices, laboratories, and workshops in Tucson, Arizona and La Serena, Chile.

NOAO-Development: $3.40 million: This supports the modernization of telescopes as well as the development of new instrumentation for telescopes at KPNO and CTIO. The 2006 NSF Senior Review recommended that the instrumentation at KPNO and CTIO urgently be modernized. In FY 2010 NOAO began a multi-year effort to introduce new capabilities to the U.S. community. Three new instruments are under development – two are expected to be put on telescopes in 2013 and the third will be available in 2015.

NOAO-Research and Education: $600,000: NOAO links the research conducted at its facilities to education of the public through its education and public outreach office in Tucson.

LSST: $1.50 million: These funds support design, development, and planning activities for future construction of the LSST telescope, site, and enclosure in Chile, as well as for engaging the astronomical community in developing science missions for research using the LSST data sets.

Management and Oversight

- NSF Structure: An NSF program director in the Division of Astronomical Sciences (AST) provides continuing oversight, including consultation with an NSF Program Review Panel that meets twice a year. The program director reviews detailed annual program plans, annual long range plans, quarterly technical and financial reports, and annual reports submitted by NOAO, and attends AURA governance committee meetings. Governance committees are formed from the national astronomical community and provide additional windows into community priorities and concerns. The AST program manager works closely with other offices at NSF, particularly the Office of General Counsel, and the Division of Acquisition and Cooperative Support and the Large Facilities Office in the Office of Budget, Finance, and Award Management.
- External Structure: AURA is the managing organization for NOAO. The NOAO director reports to the president of AURA, who is the principal investigator on the FY 2009 NSF cooperative agreement. AURA receives management advice from an observatory council composed of members of its scientific and management communities. NOAO employs separate visiting and users committees for the purposes of self-evaluation and prioritization. The visiting committees, composed of nationally prominent individuals in science, management, and broadening participation, review for AURA all aspects of the management and operations of the observatories. User committees, composed of scientists with considerable experience with the observatories, review for the NOAO Director all aspects of user experiences at the observatory.
- Reviews: In addition to reviews held mid-way through all cooperative agreements, NSF conducts both periodic and ad hoc external reviews of AURA management. A Business Systems Review (BSR) is underway during FY 2013. A mid-term management review is being planned.

Renewal/Recompetition/Termination

A management review of AURA's performance was carried out in August 2006. In response to the review, the National Science Board extended the previous cooperative agreement with AURA for eighteen months, through September 30, 2009. A proposal for renewal of the cooperative agreement was received from AURA in December 2007 and underwent review in 2008. The National Science Board authorized a new cooperative agreement with AURA for the management and operation of NOAO for the period October 1, 2009, through March 31, 2014. AST plans to extend the current cooperative agreement through FY 2015 to allow for the possible implementation of Portfolio Review recommendations that could significantly alter NOAO's operations and hence the scope of the work for the managing organization. A solicitation is being developed and will be promulgated in late 2013 for the management of NOAO under a new cooperative agreement to begin October 1, 2015.

NATIONAL RADIO ASTRONOMY OBSERVATORY

$77,410,000
+$5,660,000 / 7.9%

National Radio Astronomy Observatory
(Dollars in Millions)

FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request	Change over FY 2012 Enacted Amount	Percent
$71.75	$71.75	$77.41	$5.66	7.9%

Totals may not add due to rounding.

The National Radio Astronomy Observatory (NRAO) provides state-of-the-art radio telescope facilities for scientific users. NRAO conceives, designs, builds, operates, and maintains radio telescopes used by scientists from around the world to study virtually all types of astronomical objects known, from planets and comets in our own Solar System to quasars and galaxies billions of light-years away.

As a Federally Funded Research and Development Center (FFRDC), NRAO operates major radio telescopes in Green Bank, West Virginia; near Socorro, New Mexico; and at ten telescope array sites spanning the U.S. from the Virgin Islands to Hawaii. Headquartered in Charlottesville, Virginia, NRAO is the North American (N/A) implementing organization for the international Atacama Large Millimeter/submillimeter Array (ALMA) project. These federally funded, ground-based observing facilities for radio astronomy are available to any qualified astronomer, regardless of affiliation or nationality, on the basis of scientific peer-reviewed proposals, and annually serve over 1,500 users worldwide. The Observatory allocates telescope time on the basis of merit and provides some financial support to students. NSF does not provide individual investigator awards targeted specifically for use of NRAO facilities. Many users are supported through NSF or NASA grants to pursue scientific programs that require use of the facilities.

Including the ALMA operations staff located at NRAO, Observatory staff consists of 472 FTEs in the operations and maintenance components of the Observatory: 84 in Observatory Science Operations, 272 in Observatory Telescope Operations, 30 in Observatory Development Programs, 62 in Observatory Administrative Services, and 24 in the Director's Office.

The Division of Astronomical Sciences (AST) has conducted a community-based review of its entire portfolio, to allow implementation of a balanced program in budget scenarios more realistic than the scenario assumed by the National Research Council's decadal survey in astronomy and astrophysics, completed in 2010. The Portfolio Review Committee report was delivered in FY 2012, which gave very high priority ranking to two NRAO telescopes, ALMA and the Karl G. Jansky Very Large Array (VLA). The Robert C. Byrd Green Bank Telescope (GBT) and the Very Long Baseline Array (VLBA) were recommended for divestment from the AST budget because of less compelling mapping onto the science questions of the 2010 decadal survey. NSF is considering the findings and recommendations from this review, which may inform future budget allocation and planning activities.

The Atacama Large Millimeter/submillimeter Array (ALMA) will complete construction in FY 2013 and has begun science operations. ALMA, an international partnership between North America, Europe and East Asia, provides orders-of-magnitude improvement in observing sensitivity and image quality over existing facilities. *Credit: NRAO/AUI*

Total Obligations for NRAO

(Dollars in Millions)

	FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request	ESTIMATES[1] FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Operations and Maintenance	$43.14	$43.14	$41.00	$41.00	$41.00	$41.00	$41.00	$41.00
Observatory Management	*6.03*	*6.03*	*5.73*	*5.73*	*5.73*	*5.73*	*5.73*	*5.73*
Observatory Operations	*31.77*	*31.77*	*30.20*	*30.20*	*30.20*	*30.20*	*30.20*	*30.20*
Science, Acad. Affairs, EPO	*3.62*	*3.62*	*3.44*	*3.44*	*3.44*	*3.44*	*3.44*	*3.44*
Central Development Lab	*1.72*	*1.72*	*1.63*	*1.63*	*1.63*	*1.63*	*1.63*	*1.63*
ALMA Operations	28.61	28.61	36.41	39.17	39.17	39.17	39.17	39.17
Total, NRAO	**$71.75**	**$71.75**	**$77.41**	**$80.17**	**$80.17**	**$80.17**	**$80.17**	**$80.17**

Totals may not add due to rounding.

[1] Outyear funding estimates are for planning purposes only. The current cooperative agreement ends in September 2015.

Increased funding in FY 2014 supports the planned ramp up to full ALMA operations. Funding for the implementation of the VLA expansion project concluded in FY 2011.

Partnerships and Other Funding Sources: NRAO supplements Division of Astronomical Sciences (AST) support with funding provided by other NSF sources, other federal agencies, and non-federal sources. In FY 2012, NRAO received approximately $1.10 million from non-AST sources at NSF, $1.30 million from other federal agencies, and $530,000 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.

Education and Public Outreach: NRAO supports a comprehensive outreach program that makes information about radio astronomy available to the public (www.nrao.edu/index.php/learn). With over 150 students involved per year, NRAO facilities are used by graduate students carrying out dissertation research and work experience programs and by undergraduate students participating in the Research Experiences for Undergraduates (REU) program. NRAO sites also support visitor and education centers and conduct active educational and public outreach programs. The Green Bank Science Center and the visitor center at the VLA together attract over 60,000 public visitors each year.

Observatory Management, $5.73 million: This includes the director's office, administrative services, and the New Initiatives Office.

Observatory Operations, $30.20 million: This includes support for operating facilities at Green Bank, West Virginia, in New Mexico, and the computer and information services that support the facilities.

Science & Academic Affairs and EPO, $3.44 million: This area includes staff research, science training and education, science centers, the library, science community outreach, and news and public information.

Central Development Laboratory (CDL), $1.63 million: The CDL is developing next generation electronics and detectors for radio astronomy, making fundamental contributions to materials science, the physics of quantum detectors, electromagnetics, photonics, and radio propagation.

ALMA Operations, $36.41 million: NRAO is engaged in construction of the international ALMA Observatory, which in FY 2013 is in the final stages of construction, funded through the Major Research Equipment and Facilities Construction (MREFC) account. Early operations funding for ALMA began in FY 2005 and ramps up sharply from FY 2008 to FY 2015. A funding profile through FY 2015 was authorized by the National Science Board in February 2011.

As part of ALMA Operations, in 2006 NRAO created the North American ALMA Science Center (NAASC) to support the broad user community in fully realizing the scientific capabilities of ALMA. NAASC is increasing its activity in conjunction with the ramp up in ALMA operations. NAASC serves two key functions: (1) supporting basic ALMA operations as an ALMA Regional Center (ARC), providing day-to-day support for ALMA operations carried out in Chile, and (2) providing easy access and strong support to the broad astronomical community that will be using ALMA. NAASC organizes summer schools, workshops, and courses in techniques of millimeter and submillimeter astronomy.

Management and Oversight

- NSF Structure: Continuing oversight and assessment is carried out for NRAO and ALMA by dedicated AST program officers and in consultation with community representatives making use of detailed annual program plans, long-range plans, quarterly technical and financial reports, and annual reports submitted to NSF, as well as by the attendance of AST program officers and AST management at ALMA governance board and governance committee meetings of the managing organization, Associated Universities, Inc. (AUI). 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 observatory through its own community-based oversight and users' committees. The NRAO director reports to the president of AUI. Oversight of the international ALMA project is vested in the ALMA Board, whose membership includes an NSF member; coordination and management of the merged international efforts is the responsibility of the Joint ALMA Observatory (JAO) whose staff includes an ALMA director. An international ALMA Management Advisory Committee (AMAC) advises the ALMA Board.
- Reviews: NSF conducts annual reviews of the NRAO Program Operating Plan, the Long Range Plan, ALMA construction and operations, and the AUI Management Report. A Business Systems Review and mid-term Management Review were conducted in FY 2012.

Renewal/Recompetition/Termination

A management review of AUI's performance and plans was carried out in 2008. In response, the National Science Board authorized renewal of the cooperative agreement with AUI for the management and operation of NRAO for the period October 1, 2010 through September 30, 2015. Preparations are underway for a NRAO management and operations solicitation that will be promulgated in FY 2013 for a new cooperative agreement to begin October 1, 2015.

In response to guidance from the National Science Board, NSF has assessed separating the management and operation of NA ALMA from NRAO and finds that there would be significant detrimental cost, operational, and community impacts with no compensatory advantages in engendering competition. Therefore, NA ALMA will remain a part of NRAO, and the recompetition will treat them as a single entity. In addition, to sustain the scientific and operational synergies of NA ALMA and the VLA while increasing flexibility exploring cost-efficient operational models and sustainable partnerships for GBT and VLBA, NSF will separate GBT and VLBA from the upcoming competition. As noted above, further information on this recompetition will be available later this year.

OTHER FACILITIES FUNDING

Major Research Equipment and Facilities Construction Account Projects

The MREFC account supports the acquisition, construction, and commissioning of major research facilities and equipment that provide unique capabilities at the frontiers of science and engineering. Projects supported by this account are intended to extend the boundaries of technology and open new avenues for discovery for the science and engineering community. Initial planning and design, and follow-on operations and maintenance costs of the facilities are provided through the Research and Related Activities (R&RA) and Education and Human Resources (EHR) accounts.

For information on projects funded through this account, refer to the MREFC chapter of this Budget Request.

Preconstruction Planning

Within the R&RA account, funds are provided for preconstruction studies for prospective large facility projects. This funding generally supports such activities as design, cost estimates, and other actions that prepare potential projects for oversight review, agency decisions milestones, and potential implementation.