MAJOR MULTI-USER RESEARCH FACILITIES $1,106,400,000

The FY 2009 Request includes $1,106.40 million for major multi-user research facilities, a $25.51 million increase, or 2.4 percent, over the FY 2008 Estimate of $1,080.89 million. All 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.

Major Multi-User Research Facilities Funding

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Facilities	$832.60	$898.13	$907.51	$9.38	1.0%
Federally Funded R&D Centers	181.89	182.76	198.89	16.13	8.8%
Total, Major Multi-user Research Facilities	$1,014.49	$1,080.89	$1,106.40	$25.51	2.4%

Totals may not add due to rounding.

NSF investments provide state-of-the-art tools for research and education, such as multi-user research facilities, distributed instrumentation networks and arrays, accelerators, telescopes, research vessels, aircraft, and earthquake simulators. In addition, investments in internet-based and distributed user facilities are increasing as a result of rapid advances in computer, information, and communication technologies. NSF's investments are coordinated with those of other organizations, agencies, and countries to ensure complementarity and integration.

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. More information on the construction projects funded through NSF's MREFC account is provided in the MREFC chapter.

Major Multi-User Research Facilities Funding

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Request
Academic Research Fleet	$87.95	$70.66	$83.96	$13.30	18.8%
Cornell Electron Storage Ring	14.71	13.71	8.50	-5.21	-38.0%
EarthScope[1]	11.63	17.61	26.29	8.68	49.3%
Gemini Observatory	20.00	20.00	22.00	2.00	10.0%
Incorporated Research Institutes for Seismology	11.77	11.75	12.20	0.45	3.8%
Integrated Ocean Drilling Program[2]	36.81	39.26	47.74	8.48	21.6%
Large Hadron Collider	18.00	18.00	18.00	-	-
Laser Interferometer Gravitational Wave Observatory	33.00	29.50	28.50	-1.00	-3.4%
National High Magnetic Field Laboratory	26.55	26.50	31.50	5.00	18.9%
National Nanotechnology Infrastructure Network	13.32	13.50	13.50	-	-
National Superconducting Cyclotron Laboratory	18.50	18.50	20.50	2.00	10.8%
Network for Earthquake Engineering Simulation	20.74	22.17	23.02	0.85	3.8%
Other Facilities[3]	12.57	12.47	19.47	7.00	56.1%
Polar Facilities and Logistics[4]	317.46	323.54	352.25	28.71	8.9%
MREFC Projects[5]	189.60	260.96	200.08	-60.88	-23.3%
Federally Funded R&D Centers[6]					
National Astronomy and Ionosphere Center	10.46	12.15	11.40	-0.75	-6.2%
National Center for Atmospheric Research	85.12	87.54	95.87	8.33	9.5%
National Optical Astronomy Observatory and the National Solar Observatory	39.28	38.55	41.83	3.28	8.5%
National Radio Astronomy Observatory	47.03	44.52	49.79	5.27	11.8%
Grand Total	$1,014.49	$1,080.89	$1,106.40	$25.51	2.4%

[1]EarthScope funding includes support provided through the R&RA account for operations and maintenance of the facility. Support provided through the MREFC account for the construction of the project, totaling $25.93 million in FY 2007, is included in the MREFC Projects line.
[2]Funding for the Integrated Ocean Drilling Program (IODP) includes support for the continued phase out of program and contract activities for the Ocean Drilling Program, predecessor to the IODP. This line also includes support for the operations and maintenance of the Scientific Ocean Drilling Vessel; MREFC funding for the SODV, the final year of which was FY 2007, is included on the MREFC projects line.
[3]"Other Facilities" includes support for other physics and materials research facilities.
[4]Polar Facilities and Logistics includes support for the operations and maintenance of the South Pole Station. Funds provided through the MREFC account for the South Pole Station Modernization (SPSM) project are included on the MREFC Projects line.
[5]Funding levels for MREFC Projects in this table include support for concept and development associated with these projects, initial support for operations and maintenance (both provided through the R&RA account), and implementation support provided through the MREFC account. EarthScope and SODV received the final year of construction funding in FY 2007, and those MREFC funds are included here.
[6]"Federally Funded R&D Centers" does not include the Science and Technology Policy Institute, which is an FFRDC but not a research platform.

Academic Research Fleet — $87,960,000

The FY 2009 Budget Request for the Academic Research Fleet is $87.96 million, an increase of $14.80 million, or 20.2% over the FY 2008 Estimate of $73.16 million.

Academic Research Fleet
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Academic Research Fleet	$87.95	$73.16	$87.96	$14.80	20.2%

The Academic Research Fleet consists of 23 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. In addition, the Division of Ocean Sciences (OCE) has undertaken selected construction projects, based on an inter-agency fleet renewal status plan.

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

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	ESTIMATES FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Operations and Maintenance	$76.63	$66.16	$72.96	$93.92	$99.55	$105.52	$111.86	$118.57
Fleet Renewal:								
Human Occupied Vehicle	9.05	1.00	1.00	-	-	-	-	-
R/V Langseth (Seismic Ship)	0.69	2.00	-	-	-	-	-	-
Regional Class Research Vessels	1.57	4.00	14.00	20.00	20.00	20.00	20.00	20.00
Total, Academic Research Fleet	$87.95	$73.16	$87.96	$113.92	$119.55	$125.52	$131.86	$138.57

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 oceans. Scientists contribute to advances made in areas such as climate variability, marine ecosystems, fisheries, and ocean-related natural hazards such as tsunamis through use of these facilities. Vessels in the Academic Research Fleet permit shipboard training of future oceanographers. Participating graduate and undergraduate students interact with scientists and marine technicians, enabling them to gain first-hand exposure to ocean science field research. Recent technological innovations allow research conducted at sea to be transmitted via satellite back to the classroom, broadening the educational impact of the vessels to a wider audience, including K-12 students.

The Academic Research Fleet is supported through an interagency partnership, principally with the National Oceanic and Atmospheric Administration (NOAA) and the Office of Naval Research (ONR) via a Memorandum of Understanding (MOU). The operating costs for the Fleet are divided proportionally among the vessel users based on usage; NSF supports approximately 70 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 state and federal agencies. Within NSF, science is supported via competitive peer-reviewed proposals, most typically funded within OCE and through selected programs in the Divisions of Earth Sciences (EAR) and Atmospheric Sciences (ATM), and also through the Office of Polar Programs (OPP) and the Directorate for Biological Sciences (BIO). Approximately 30 percent of the GEO proposals request ship time; GEO-funded shipboard science has ranged from about $35 million to $45 million per year over the last 5 years. 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. fleet, and science funded by other agencies.

This is an image of a marine ecology class cruise for graduate students on the *Point Sur*, a ship owned by the NSF and operated by the Moss Landing Marine Laboratories (MLML) of the California State University System. for graduate students. The students are examining the contents of the trawl taken from a ridge near the mouth of the Monterey Bay at a depth of just over 500 meters.

Project Report:

Management and Oversight:

- Fleet Operations:

  - NSF provides oversight to the Academic Research Fleet through cooperative agreements with each ship-operating institution and the UNOLS Office. In addition, NSF oversees the fleet through external review of proposals, site visits, ship inspections, and participation at UNOLS Council and Subcommittee meetings by Program Managers. Several Program Managers within OCE at NSF, at NOAA, and at ONR are involved in the activities and overall oversight of the Academic Research Fleet.

  - Management of an individual 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.

- Fleet Renewal:

  - The NSF coordinator is the program director for Ship Acquisitions and Upgrades, within the Integrative Programs Section (IPS) in OCE, with additional IPS staff providing project management assistance.
  - External Structure: NSF and the Navy's Program Executive Office Ships (PEO Ships) are negotiating a new MOU to extend the cooperative relationship for the acquisition of the Regional Class Research Vessels (RCRVs) beyond the design phase. NSF and PEO Ships jointly manage the program, with PEO Ships (NAVSEA) serving as the contracting authority and providing the required personnel with expertise in ship design and acquisition, teamed with NSF personnel and other sources under a cost reimbursable agreement with NSF. In addition, a team of UNOLS Marine Superintendents and Technicians participated in Phase I of a multi-phase design process.

The UNOLS Fleet Improvement Committee will review progress and provide advice regarding scientific outfitting of the vessel.

- Reviews Conducted: 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. In coordination with the other federal agencies with ocean research investments and UNOLS, the Interagency Working Group for Facilities (IWG-F) has revised the 2001 report on long-range plans for renewal of the federal and academic oceanographic research and survey fleet and it will be published this year. In addition, several activities are requested or underway to support the upgrade of the U.S. Academic Research Fleet. Ship operations and technical activities are internally reviewed yearly on the basis of detailed annual reports provided by the operating institutions. Ship operations proposals undergo external merit review every five years, with annual negotiation of the cooperative agreements. Technical services awards are reviewed every three years and negotiated annually.

Fleet Renewal: Current Status:

- Ongoing activity in FY 2009 includes:

  - Continued development and construction of a new deep submergence capability to replace the pioneering submersible human occupied vehicle (HOV) ALVIN. This project, begun in FY 2004, will take a total of six years and cost approximately $22.0 million; an increase over previous estimates due to rise in titanium costs.
  - A design competition is underway for construction of a series of up to three Regional Class Research Vessels (RCRVs), and two U.S. shipyard/design agent consortia are working to each produce a design and bid on construction by summer 2009.
  - Outfitting of the Research Vessel (R/V) *Langseth* will be completed in FY 2009.

Renewal/Recompetition/Termination: The R/V *Alpha Helix*, which previously supported research activities in the Alaska region, was sold by the University of Alaska for $680,000. Funds are being held by the institution pending direction from NSF on proper use of those funds. Potential uses include future operation support of the Alaska Region Research Vessel and instrumentation development for this new vessel. This 40 year old *Alpha Helix* was the oldest in the fleet and was in use well beyond the normal lifetime of a research vessel.

Cornell Electron Storage Ring — $8,500,000

The FY 2009 Budget Request for the Cornell Electron Storage Ring (CESR) is $8.50 million, a decrease of $5.21 million, or 38.0 percent, from the FY 2008 Estimate of $13.71 million.

Cornell Electron Storage Ring
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Cornell Electron Storage Ring	$14.71	$13.71	$8.50	-$5.21	-38.0%

CESR is a facility that supports research in elementary particle physics as well as research in accelerator physics and superconducting radio frequency (RF) applications. The funding profile presented above is targeted toward the planned close-out of the particle physics program based upon the CESR accelerator.

With the closeout of the particle physics program at CESR, physicists at Cornell, building upon their technical and analytical expertise, are ramping up their participation in the research program of the Compact Muon Solenoid (CMS) experiment, one of the two major detectors at the CERN Large Hadron Collider (LHC). During this final funding period, a vigorous program of accelerator science and technology development for accelerator concepts for the future will continue.

CESR is an electron-positron collider that provides important knowledge of the properties of the b-quark. A modified CESR (CESR-c) and the associated particle detector, CLEO-c, address high-priority physics questions that relate to the c-quark and possible gluon states that cannot be addressed elsewhere. The CESR facility is also used by the materials research community at the Cornell High Energy Synchrotron Source (CHESS). CHESS is a high-intensity, high-energy X-ray source supported by NSF. It uses the synchrotron light given off by the charged particles, both electrons and positrons, as they circulate at nearly the speed of light around CESR. As a user facility, CHESS provides state-of-the-art synchrotron radiation facilities for research in physics, chemistry, biology, materials research and environmental sciences.

Total Obligations for CESR
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	ESTIMATES FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Operations and Maintenance	$14.71	$13.71	$8.50	-	-	-	-	-

CESR-c and CLEO-c explore a large set of critical weak and strong interaction phenomena that drive theoretical advances that extend and enable the full program of physics targeted by new-generation detectors and lay the foundation for strong interaction theory to meet the requirements of future physics beyond the Standard Model. It is expected that that the CESR-c and CLEO-c projects will cease by the close of FY 2009 as the Large Hadron Collider (LHC) begins operations. Scientific research at CESR supports and enhances doctorate level graduate education, postdoctoral research experience, research experiences for undergraduates, and research experiences for K-12 science teachers. Engendering excitement in science among young children is a focus for K-12 engagements. An important component of this effort is the participation of CLEO and CESR graduate students in school science classrooms.

CESR staff transfers CESR Superconducting RF (SRF) technology to industry. Through a license arrangement with Cornell, the ACCEL Corporation has manufactured two superconducting RF sources to power synchrotron light sources. They have been tested and installed in CESR to replace two older, lower gradient modules. Also, some of the CHESS users are from industry, including pharmaceutical corporations (Rib-x Pharmaceuticals) and the research arms of Eastman Kodak, Xerox and General Motors. Some medical institutions also make use of CHESS (Dana Farber Cancer Institute, Boston Biomedical Research Institute, and Memorial Sloan-Kettering Institute).

Project Report:

Management and Oversight:

- NSF Structure: NSF oversight is provided through the Division of Physics (PHY) of the Directorate for Mathematical and Physical Sciences (MPS) and by periodic site visits by NSF staff. Technical review of the award involved panel evaluation of the CESR-c proposal, and a site visit by NSF staff and external reviewers. The oversight process includes annual financial reports and program reports to the NSF and an annual review by a Program Advisory Committee of outside physicists reporting to the Laboratory Director and NSF.

  CHESS is supported through the Division of Materials Research (DMR) of MPS, the Directorate for Biological Sciences (BIO), and by the National Institutes of Health (NIH). These organizations provide management oversight for CHESS through regular site visits.

- External Structure: CESR-c is managed by the Director of the Laboratory for Elementary Particle Physics (LEPP) at Cornell with help from an Assistant Director and an Associate Director for Accelerator Physics. The CLEO-c experiment is the sole experiment in particle physics at CESR-c, and this collaboration consists of users from about 20 U.S. institutions. The CESR-c management interacts with the CLEO-c collaboration through the collaboration spokesperson and executive board as needed, and there are monthly meetings of the collaboration that include CESR-c management.

- Reviews:
  - Reviews Conducted:
    - Proposal review for continued operations, FY 2003
    - Comprehensive site review with panel of external experts, FY 2006
  - Upcoming:
    - Review for phase-out of facility operations, FY 2008

Renewal/Recompetition/Termination:

CESR is currently funded through the five-year cooperative agreement initiated in April 2003. Use of CESR as a facility for particle physics will conclude with final phase-out over FY 2008 and FY 2009. Proposals for the continuation of CHESS as a user facility for synchrotron radiation after the phase-out of the particle physics program are presently under consideration.

EarthScope $26,290,000

The FY 2009 Budget Request for EarthScope is $26.29 million, an increase of $8.68 million, or 49.3 percent over the FY 2008 Estimate of $17.61 million. FY 2007 represented the final year of MREFC appropriations for the EarthScope project; no funds are requested in FY 2009 through the MREFC account. Construction continues through FY 2008.

EarthScope
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
EarthScope	$37.55	$17.61	$26.29	$8.68	49.3%

The EarthScope Facility is a distributed, multi-purpose geophysical instrument array that is making major advances in our knowledge and understanding of the structure and dynamics of the North American continent. EarthScope instrumentation is expected to be located in nearly every county within the U.S. over the life span of the program.

Total Obligations for EarthScope
(Dollars in Millions)

	Prior Years	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	ESTIMATES FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
R&RA Obligations:									
Concept & Development	9.36	-							
Management and Operations	13.51	11.63	17.61	26.29	25.00	25.50	26.00	26.50	27.00
Subtotal, R&RA Obligations	$22.87	$11.63	$17.61	$26.29	$25.00	$25.50	$26.00	$26.50	$27.00
MREFC Obligations:									
Implementation	170.04	25.93	4.21	-					
Subtotal, MREFC Obligations	$170.04	$25.93	$4.21	-	-	-	-	-	-
Total: EarthScope Obligations	**$192.91**	**$37.55**	**$21.82**	**$26.29**	**$25.00**	**$25.50**	**$26.00**	**$26.50**	**$27.00**

EarthScope seeks to enhance the understanding of the structure and evolution of the North American continent, including earthquakes and seismic hazards, magmatic systems and volcanic hazards, lithospheric dynamics, regional tectonics, continental structure and evolution, fluids in the crust, and associated educational aspects. Science and non-science students will be engaged in geosciences discovery through the use of technology in real time or retrospectively with the aim of integrating research and education.

The U.S. Geological Survey (USGS), the National Aeronautics and Space Administration (NASA), the Department of Energy (DOE), and the International Continental Scientific Drilling Programme are funding partners, with USGS and NASA expected as operating partners. Project partners may also include state and local governments, geological and engineering firms, and Canadian and Mexican agencies. Over 3,000 earth scientists and students are expected to use the facility annually. Geotechnical and engineering firms directly use data and models, which are enabled by EarthScope. Instrumentation

firms are collaborating on development for state-of-the-art seismic systems, down-hole instrumentation, and high-precision GPS antenna designs.

Along with direct operations and maintenance support for the EarthScope Facility, NSF will support research performed utilizing the facility through ongoing research and education programs. The annual support for such activities is estimated to be about $15.0 million once the facility reaches full operations in FY 2009.

The project continues to move forward approximately on time and within budget, with completion anticipated by the close of FY 2008.

Project Report:

Management and Oversight:

- NSF Structure: The EarthScope Program Director, located in the Earth Sciences (EAR) Division in the Directorate for Geosciences (GEO), provides NSF oversight. The Deep Earth Processes Section Head (EAR) and a Project Advisory Team, including the staff from GEO, the Office of the General Counsel (OGC) and staff from the Office of Budget, Finance and Award Management (BFA), including the Deputy Director for Large Facility Projects, provide other internal oversight.

- External Structure: Following the recommendations of the Large Facilities Management and Oversight guideline documents, external oversight is provided through periodic reviews, including facility construction project baseline reviews and ad hoc technical, science, and education and outreach committee meetings, as well as site visits.

- Reviews: The EarthScope facilities are formally reviewed annually during the construction phase, with NSF and EarthScope's managers conducting a combined site visit and review of each of the three components. Each November, NSF convenes a panel of external experts to review project management, cost, schedule, and technical status of the EarthScope facilities and provide advice for the EarthScope managers and NSF.

Current Project Status:

The third and final phase of drilling was conducted at the San Andreas Fault Observatory at Depth (SAFOD) site during 2007. Tens of feet of continuous core was collected across the active traces of the San Andreas Fault system. Research on the core is just beginning. The Plate Boundary Observatory (PBO) has installed more than 770 permanent geodetic stations, 30 borehole strainmeter stations, and three long-baseline strainmeters. The USArray has installed more than 400 Transportable Array stations, and installations continue on schedule. Other highlights include the combined use of PBO geodetic and strain data and USArray seismic data in analyses of "slow earthquakes" in the Cascadia subduction system. The

A remote EarthScope instrument installation.
Credit: EarthScope.

EarthScope project has been represented at several dozen professional meetings and conferences through an exhibit booth, presentations, and scientific sessions. Scientific results utilizing data collected by the EarthScope facility have already been presented at national meetings and in professional publications.

Cost, Schedule, and Risks

- As of October 31, 2007, EarthScope was 4 percent behind schedule and 2 percent under budget for the work completed. Eighty two percent of the planned construction of the EarthScope facility is complete. Overall, the effort is almost exactly on budget and on schedule.

- There are no remaining major risks to a successful completion of the construction of EarthScope; however, some minor risks associated with fluctuating shallow drilling costs and permitting issues for some equipment installations remain.

Operations costs

These costs are anticipated to remain approximately steady at about $24 million, with adjustments for inflationary effects. The 2009 Request exceeds this level as the FY 2008 Estimate does not fully support the targeted operation level through FY 2009.

Gemini Observatory **$22,000,000**

The FY 2009 Budget Request for the Gemini Observatory is $22.00 million, an increase of $1.50 million, or 7.3%, above the FY 2008 Enacted Level of $20.50 million.

Gemini Observatory
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Gemini Observatory	$20.00	$20.50	$22.00	$1.50	7.3%

The Gemini Observatory consists of two 8-meter telescopes, one in the northern hemisphere, in Hawaii, and one in the southern hemisphere, in Chile. The Hawaiian telescope, Gemini North, is optimized for infrared observations and is located on Mauna Kea at an altitude of 4,200 meters. The telescope in Chile, Gemini South, is located on Cerro Pachon, also an outstanding photometric site, 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. It provides access to 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.

Total Obligations for the Gemini Observatory
(Dollars in Millions)

	FY 2007	FY 2008	FY 2009	ESTIMATES				
	Actual	Estimate	Request	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Operations and Maintenance	$20.00	$20.50	$22.00	$25.66	$26.17	$26.70	$27.25	$27.80

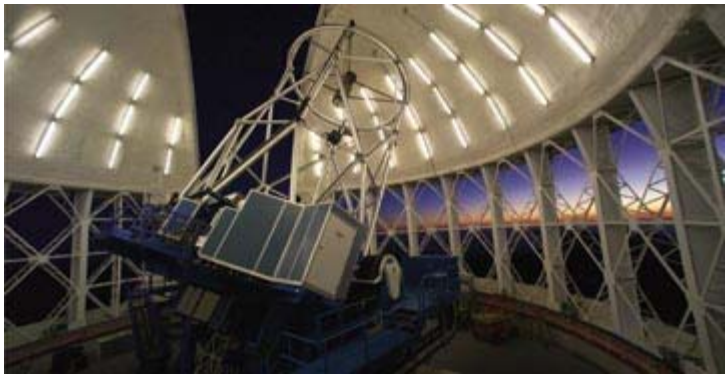
Astronomers need to resolve important questions about the age and rate of expansion of the universe, its overall topology, the epoch of galaxy formation, the evolution of galaxies once they are formed, and the formation of stars and planetary systems. The new generation of optical/infrared telescopes with significantly larger aperture (8-meter diameter) than previous instruments provides better sensitivity and spectral and spatial resolution. Technological advances in a number of key areas of telescope construction and design optimize the telescopes' imaging capabilities and infrared performance, and compensate for the blurring effects of the earth's atmosphere.

The Gemini telescopes play a central role in the education and training of 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 also provides guidance and support to the Imiloa Science Center, a public astronomy and cultural center in Hilo.

Gemini is an international partnership with the United Kingdom, Canada, Australia, Chile, Argentina, and Brazil. Construction of the telescopes and their instrumentation has involved a large number of industrial entities in a number of partner and non-partner countries. These have involved firms specializing in large and/or complex optical systems, aerospace industries, electronics and engineering, etc. Continued

involvement of such industries is part of the instrumentation and facilities renewal activities included in the operating budget of the 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 NSF or NASA grants to pursue scientific programs that require use of Gemini.



This image shows the Gemini North Telescope on the evening of April 19th, 2005 during evening twilight. Featured on the foreground of the telescope is the laser guide star (LGS) clean-room (blue box with white door). The Gemini solid-state sodium laser is located in this box and shines up through a network of tubes and relay optics (also visible) where the beam is "launched" by optics located behind the secondary mirror. *Credit: Gemini Observatory*

Laser guide star systems, which greatly improve the telescopes' ability to correct for atmospheric blurring, are being developed for both telescopes with the laser on Gemini North in routine operation and integration of the system on Gemini South underway. An advanced 'multi-conjugate' adaptive optics system, which will yield crisp images over a larger field of view, is in development on Gemini South and will start scientific operation in FY 2009. Several new instruments are in various states of development, including: (1) an improved infrared spectrometer, to be delivered in FY 2008; (2) the construction of the Gemini Planet Imager, a camera designed to directly detect planets around nearby stars; and (3) design studies for a very wide-field optical spectrometer that will collect data from thousands of objects simultaneously.

Changes in the budget profile from the FY 2008 Enacted Level are a result of the availability and inclusion of more realistic estimates of partner countries' funding for next generation instrumentation. Projections for FY 2010 and beyond also reflect the decision on the part of the United Kingdom (UK) to withdraw from the partnership. While the final disposition of the UK share is under discussion, the likely outcome is that it will be split between the U.S. and Australia. The FY 2010 estimate reflects an increase in the U.S. share of Gemini from 50.1% to 65%. Final disposition of the UK share should be determined in mid-2008.

Facility Report

Management and Oversight:

- NSF Structure: Programmatic management is the responsibility of an assigned program manager for Gemini in the Division of Astronomical Sciences in MPS.

- 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 seven-nation partnership, carrying out the project on their behalf. An independent Visiting Committee, established by the Gemini Board, advises on the operation of the Observatory and meets bi-annually. Gemini is 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.

- Reviews: In addition to a review held mid-way through the cooperative agreement, NSF conducts periodic reviews of AURA management and observatory programs as requested by the Gemini Board. The observatory's adaptive optics program was reviewed by an external committee in September 2007, and the computing and data reduction program was reviewed in December 2007.

Renewal/Recompetition/Termination:

Under the terms of the international agreement, the partnership conducted a management review in 2004 and determined that it would not compete the management of the Observatory at that time. A cooperative agreement for the period FY 2006-2010 is currently in place. A mid-term management review of AURA's performance will be conducted in fall 2008, on the basis of which the Gemini Board will decide whether to compete the management of the observatory.

The current International Gemini Agreement will expire in 2012. The Gemini Board has begun the discussion of the process and schedule for renegotiation of the Agreement, given the UK's recent decision to withdraw.

Incorporated Research Institutions for Seismology $12,200,000

The FY 2009 Budget Request for Incorporated Research Institutions for Seismology (IRIS) is $12.20 million, an increase of $450,000, or 3.8 percent, over the FY 2008 Estimate of $11.75 million.

Incorporated Research Institutions for Seismology
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Incorporated Research Institutions for Seismology	$11.77	$11.75	$12.20	$0.45	3.8%

IRIS is a consortium of 104 U.S. universities and non-profit institutions with research and teaching programs in seismology. IRIS operates a distributed national facility for the development, deployment, and operational support of modern digital seismic instrumentation to serve national goals in basic research in the earth sciences, in earthquake research, and in nuclear test ban monitoring. IRIS is also leading the construction of the USArray component of the EarthScope project.

Total Obligations for IRIS
(Dollars in Millions)

	FY 2007	FY 2008	FY 2009	ESTIMATES				
	Actual	Estimate	Request	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Operations and Maintenance	$11.77	$11.75	$12.20	$12.50	$12.80	$13.10	$13.50	$13.90

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 national and international seismology community, IRIS is organized in four major program elements:

1. The Global Seismographic Network (GSN), which currently consists of a global deployment of over 140 permanently installed digital seismic stations, most of which have real-time data access;
2. The Program for Array Seismic Studies of the Continental Lithosphere (PASSCAL), which manages a pool of portable seismometers that are made available to the seismology research community for scheduled regional and local scale studies;
3. The IRIS Data Management System (DMS), which provides the national and international seismic research community with timely access to data from the GSN and PASSCAL (70 terabyte archive); and
4. The IRIS Education and Outreach (E&O) Program, which enables audiences beyond seismologists to access and use seismological data and research for educational purposes, including teacher workshops, student internships, museum exhibits, educational materials, and programs for under-resourced schools.

In addition to its role in providing the observational data essential for basic research in geophysics and earthquake dynamics, IRIS plays a significant role in seismic monitoring of the Comprehensive Test Ban Treaty, and in bringing seismology to students and the public through the activities of its education and outreach program.

IRIS 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 IRIS GSN stations are designated as the official stations for nuclear test ban monitoring in their host countries. The IRIS facilities also are 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 to IRIS for accelerated development of the GSN (Department of Defense), shared operation and maintenance of the GSN (U.S. Geological Survey), and accelerated development of the PASSCAL instrument pool (Department of Energy).

The use of IRIS PASSCAL instruments for investigations of the shallow crust 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 EAR/Geophysics, Tectonics, and Continental Dynamics Programs; the OCE/Marine Geology and Geophysics Program; and the OPP/Antarctic Research Section (Geology and Geophysics and Glaciology Programs) provide most of the funds for NSF-sponsored research making use of the IRIS facilities, totaling approximately $15 million per year. Funds permit deployment of PASSCAL instruments and use of GSN data stored at the DMS to solve major earth science problems.

This is an image of the entrance to the Global Seismic Network's seismic vault on Tristan da Cunha in the South Atlantic. This station is part of a collaboration with the Comprehensive Test Ban Treaty Organization International Monitoring System and Geoscope. *Credit: Ted Kromer.*

Facility Report:

Management and Oversight

- NSF Structure: The Division of Earth Sciences (in GEO), through its Instrumentation & Facilities Program (IF), provides IRIS with general oversight to help assure effective performance and administration. The program also facilitates coordination of IRIS programs and projects with other NSF-supported facilities and projects and with other federal agencies and evaluates and reviews the scientific and administrative performance of IRIS.

- External Structure: IRIS is incorporated as a non-profit consortium representing practically all U.S. university and non-profit organizations with research and teaching programs in seismology. Each member institution appoints a representative. However, all IRIS program and budget decisions are made by a nine-member Board of Directors. These decisions are made after consultation with the IRIS advisory committees (the four standing committees for each of the four IRIS programs and additional ad hoc working groups appointed for special tasks). The Board of Directors appoints a president of IRIS to a two-year term. The president is responsible for IRIS operations, all of which are managed through the IRIS Corporate Office.

- Reviews & Renewal: 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 recent and planned review schedule for IRIS is outlined below.

- Reviews:
  - Management review: March, 2004.
  - Renewal proposal reviewed, cooperative agreement awarded: May, 2006
  - Upcoming: Mid-award review, 2009

Renewal/Recompetition/Termination:

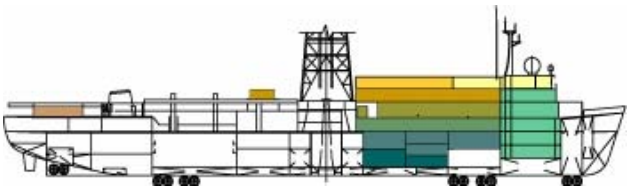
An NSF review of IRIS management in coordination with IRIS and its appropriate governance committees was completed in 2004. This review provided more information for the basis of the decision to allow the submission of a renewal proposal rather than to recompete the operation of this facility. A new five-year cooperative agreement with the IRIS Consortium for the continued management of the IRIS facilities (2006-2011) was approved by the NSB in May 2006 and finalized in September 2006.

The Integrated Ocean Drilling Program for use of the Scientific Ocean Drilling Vessel — $47,740,000

The FY 2009 Budget Request for operation of the Integrated Ocean Drilling Program (IODP) is $47.74 million, an increase of $8.48 million, or 21.6 percent, over the FY 2008 Estimate of $39.26 million. FY 2007 represented the final year of MREFC appropriations for the SODV project; no funds are requested through that account in FY 2009.

The Integrated Ocean Drilling Program
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Integrated Ocean Drilling Program	$34.71	$39.26	$47.74	$8.48	21.6%



The Integrated Ocean Drilling Program (IODP), which began in FY 2004, is an expanded successor program to the Ocean Drilling Program (ODP) and represents an international partnership of more than 20 national funding organizations, scientists, and research institutions organized to explore the evolution and structure of Earth as recorded in the ocean basins. The IODP is co-led by NSF and the Ministry of Education, Culture, Sport, Science and Technology (MEXT) of Japan. 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 seafloor.

Total Obligations for IODP Facility Operations
(Dollars in Millions)

	FY 2007	FY 2008	FY 2009	ESTIMATES				
	Actual	Estimate	Request	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Operations and Maintenance	$34.71	$39.26	$47.74	$49.65	$51.64	$53.70	$55.85	$58.08

The IODP Scientific program includes emphasis on the following research themes:

- Deep Biosphere and the Sub-seafloor Ocean.
- Processes and Effects of Environmental Change.
- Solid Earth Cycles and Geodynamics, including study of tsunami-producing seismogenic zones and other geohazards.

Undergraduate and graduate students participate in drilling expeditions, working with leading scientists to help become future leaders themselves. Other students and the public are engaged in geoscience discovery through distance learning initiatives (including remote broadcasts from the drillship), classroom

teaching modules on IODP research initiatives, outreach displays for museums and educational/teaching institutions, and lecture programs. In FY 2007, an estimated 180,000 K-12, 10,000 undergraduate and 10,500 graduate students engaged in or were supported by IODP education and outreach efforts, as were 35,000 teachers.

MEXT and NSF are equal partners in IODP and contribute equally to program operation costs. The European Consortium for Ocean Research Drilling (ECORD) – representing 16 European countries and Canada – the People's Republic of China, and Korea have officially joined IODP and provide financial contributions. India and Australia have also announced their intention to join the partnership. IODP partners, including NSF, support IODP integrative activities including science planning, review, data management, drilling science-related engineering development, core and sample archiving, publishing, and international outreach.

Over 2,000 scientists from 40 nations have participated on ODP and IODP expeditions since 1985, including about 900 U.S. scientists from over 150 universities, government agencies, and industrial research laboratories. Samples and data have been distributed to more than 800 additional U.S. scientists.

NSF is contracting the services of the light drillship from a leading offshore drilling contractor. A commercial contractor provides downhole-logging services. In addition, scientists from industrial research laboratories propose and participate in IODP cruises, are members of the program's scientific and technical advisory committees, and supply data for planning expeditions and interpretation of drilling results.

Operations and maintenance support for IODP includes the costs of operating the platform itself, providing technical scientific support, maintaining data bases and preparing scientific publications emerging from IODP expeditions, and management of the international program. In addition, NSF will support research enabled by the facility, through ongoing research and education programs. The annual costs for such science support are estimated to be about $11 million. Operations and maintenance costs are based on NSF experience in management of the ODP and the contract with the Scientific Ocean Drilling (SODV) operator.

The Scientific Ocean Drilling Vessel *JOIDES Resolution* in drydock at the Jurong Shipyard in Singapore undergoes blasting and painting in July 2007. *Credit: NSF.*

Facility Report:

Management and Oversight:

- NSF Structure: The Division of Ocean Sciences (in GEO) manages the SODV and 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 on the Central Management Office (CMO) and System Integration Contractor (SIC) contracts.

- External Structure: NSF and MEXT have signed a Memorandum of Cooperation, which identifies procedures for joint management of a contract to an IODP CMO. 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. 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. Drillship providers are responsible for platform operational management and costs. NSF provides the light drillship through contract with the U.S. SIC, an alliance formed by the Consortium for Ocean Leadership, Inc. (COL) together with subcontractors 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 scientific advisory structure (SAS). The SAS consists of a Science Advisory Structure Executive Committee (SASEC) and a series of committees, panels, and groups headed by the Science Planning Committee (SPC). The CMO, under the direction of the SPC Chair, is responsible for the coordination of the SAS committees, panels, and groups, and for integrating the advice from the advisory structure in a manner suitable for providing drilling and operational guidance to the CMO. Membership in the SAS is proportional to IODP member's financial contribution.

- Reviews: Both the CMO and SIC contracts call for management reviews every three years by independent, external panels. The SIC contract is scheduled to undergo external review in FY 2008, with the CMO contract to undergo external review in FY 2009. In addition, NSF is conducting Business System Reviews of both contracts in the FY 2008- FY 2009 timeframe. Reviews for each expedition are carried out on a regular basis to evaluate operational and scientific performance.

Renewal/Recompetition/Termination:

IODP international agreements and contracts cover activities through FY 2013. Activities regarding IODP renewal, including overall program review, are expected to commence in FY 2011.

Scientific Ocean Drilling Vessel (SODV)

The SODV project was funded through the MREFC account and supported the contracting, conversion, outfitting and acceptance trials of a deep-sea drilling vessel for long-term use in the IODP. The outfitted drillship will be capable of operating in nearly all ocean environments, subject to limitations regarding minimum water depth and surface ice coverage. It will be able to accommodate a scientific and technical staff of up to 60 persons. FY 2007 represented the final year of appropriations for the SODV project. Construction activities will continue into early FY 2008.

Appropriated MREFC Funds for the SODV
(Dollars in Millions)

FY 2005	FY 2006	FY 2007	Total
$14.88	$57.23	$42.88	$115.00

Totals may not add due to rounding.

Baseline History: NSF first requested $40.85 million for the first year of a two year construction phase of the SODV in FY 2005. The total estimated cost of the project was $100.79 million. Congress appropriated $14.88 million in FY 2005, and a contract for refit and operation of the SODV was awarded in 2005. A preliminary baseline was established during a June 2006 Review for NSF and the SODV

Independent Oversight Committee in response to the shift in the anticipated funding stream. The baseline could not be fully defined at that time since the cost of a principal element of the project, the shipyard conversion contract, was not yet available. During FY 2007, it was necessary to make significant adjustments to the proposed design in order to remain within the requested budget, reducing the overall length of the ship, but still making possible renovations and significant enhancements to the laboratory space, science instrumentation, propulsion capabilities, and the number of available scientific berths on-board Following contract award in 2007, a SODV Baseline Review Panel was convened by NSF, and the formal baseline was established and integrated into the Earned Value Management Reporting System used to track actual performance against planned baseline.

Project Report:

Management and Oversight:

- NSF Structure: The project is overseen by a program director in the Division of Ocean Sciences in the Directorate for Geosciences. The program director receives advice and oversight support from a NSF Project Advisory Team, which consists of representatives from GEO, the Office of Polar Programs, the Office of Budget, Finance and Award Management, and the Office of General Counsel. The BFA Deputy Director for Large Facility Projects is a member of the PAT and provides advice and assistance.

- External Structure: A SODV Independent Oversight Committee provides technical, financial and scheduling recommendations and advice for the SODV project to top-level management. A Program Advisory Committee (PAC), composed of members of the science and drilling communities, provides ongoing assessment of the design plans for the on-board science and drilling capabilities, which will serve to assure that the converted vessel reflects the needs of the scientific communities.

- Reviews:
  - Technical reviews: A final acceptance review process will be performed by the contractor responsible for the ship conversion activity as well as NSF.

Current Project Status:

In September 2003, NSF awarded a contract to Joint Oceanographic Institutions, Inc. (JOI [now the Consortium for Oceanographic Leadership, COL]) for IODP drilling operations, which includes the planning and implementation of the SODV project. JOI issued a request for proposals (RFP) to acquire, upgrade, and operate a commercial vessel for scientific ocean drilling. The contract was awarded to Overseas Drilling Limited in December 2005. The SODV Project received a total NSF contribution of $115 million; the ship operator, ODL, is providing an additional $15 million of construction costs in exchange for a higher day rate charge during the operations phase. Shipyard conversion of the vessel is currently underway, with a contract delivery date of March 31, 2008.

Cost and Schedule:

The SODV ship is currently being refitted in the shipyard under a fixed price contract. Work is more than three quarters complete, and the ship is expected to ready to conduct research in mid 2008, about one-half year later than originally planned. Due to the enormous worldwide demand for shipyard services, the shipyard work progressed more slowly than originally planned.

Risks

Principal risks at this stage of the project are Shipyard Cost Growth, Science Equipment Test and Integration, and Shipyard Schedule. A risk management plan is in place and highest level risks are reviewed continuously by the SODV Conversion Management Team and regularly by the SODV Independent Oversight Committee.

Future Operations Costs: Future operations costs are described in the IODP section above.

Large Hadron Collider — $18,000,000

The FY 2009 Budget Request for the Large Hadron Collider (LHC) is $18.0 million, level with the FY 2008 Estimate of $18.0 million.

The Large Hadron Collider
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Large Hadron Collider	$18.00	$18.00	$18.00	-	-

The LHC, an international project under construction at the CERN laboratory in Geneva, Switzerland, will be the premier facility in the world for research in elementary particle physics. The facility will consist of a superconducting particle accelerator providing two, counter-rotating beams of protons, each beam having an energy up to 7 TeV ($1TeV=10^{12}$ electron volts). 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) that have been built to characterize the different reaction products produced in the very high-energy proton-proton collisions that will occur in intersection regions where the two beams are brought together. A total of 34 international funding agencies participate in the ATLAS detector project, and 31 in the CMS detector project. NSF and the Department of Energy (DOE) are providing U.S. support. CERN is responsible for meeting the goals of the international LHC project. The ATLAS and CMS detectors are expected to take data approximately 200 days per year. The remaining time is to be used for maintenance and testing.

The U.S. LHC collaboration has been a leader in the development of Grid-based computing. The Grid will enable the enhanced participation of U.S. universities, and thus the training of students, in both state of the art science and computational techniques, in a project that is centered overseas. The Grid is expected to have broad application throughout the scientific and engineering communities.

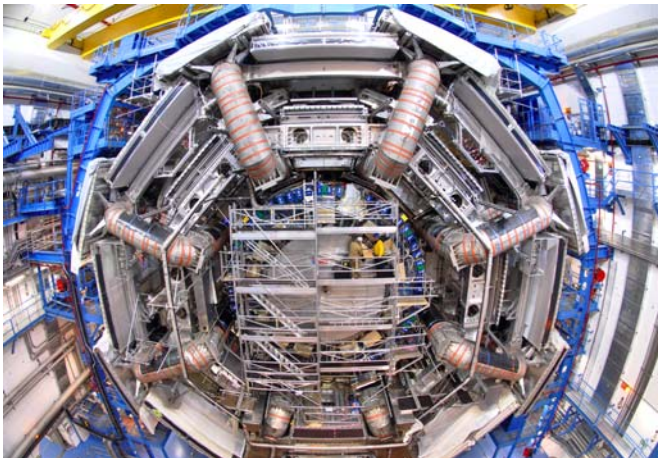
Total Obligations for the LHC
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	ESTIMATES FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Operations and Maintenance	$18.00	$18.00	$18.00	$18.00	$18.00	$18.00	$18.00	$18.00

The LHC will enable a search for the Higgs particle, the existence and properties of which will provide a deeper understanding of the origin of mass of known elementary particles. The LHC will also enable a search for particles predicted by a powerful theoretical framework known as supersymmetry, which will provide clues as to how the four known forces 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 the URL: http://quarknet.fnal.gov). Many highly-trained students in high-energy physics move into industrial jobs.

Major procurements of components of both warm and superconducting magnets, as well as high-speed electronics, are performed through U.S. industries. Major developments in Grid computing are also valuable outcomes. In the construction phase, approximately $45 million was devoted to materials procurements from industry. In FY 2009, the estimate for material procurements is approximately $4 million, which is included within the $18 million operating costs.

The U.S. LHC Collaboration is in the midst of completing the installation of detector components in the experimental areas and has begun the integration of these components with the rest of the detectors and the commissioning of the detectors using cosmic rays. This effort is proceeding on schedule and on budget. First beams from the accelerator are expected in late FY 2008, after which the detector commissioning will proceed using the particle beams and will continue into FY 2009. Data-taking is expected to begin in FY 2009 when the beam performance stabilizes.



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

Facility Report:

Management and Oversight:

- NSF Structure: A program director in the Division of Physics (PHY) is responsible for day-to-day project oversight. The NSF program director also participates in an internal Project Advisory Team, including staff from the Offices of Budget Finance and Award Management, General Counsel, Legislative and Public Affairs, the Office of International Science and Engineering, and the Office of the Assistant Director for MPS.

- 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.

- Reviews: There is one major management/technical review each year with a panel of external, international experts as well as one review by NSF/DOE program directors to monitor the progress on issues raised at the panel reviews. In addition, there are two JOG review meetings per year to monitor overall program management.

Renewal/Recompetition/Termination:

The LHC project is expected to continue at least through to the end of the next decade. Since the present award goes through FY 2011, it will require a renewal. The U.S. LHC collaboration is part of an international collaboration where the U.S. contribution to the detector construction and operations is intimately connected to that of its international collaborators. Under these circumstances it would be difficult, if not unrealistic, to consider recompeting the U.S. role in the international collaboration when the present award ends.

Laser Interferometer Gravity Wave Observatory $28,500,000

The FY 2009 Budget Request for the Laser Interferometer Gravity Wave Observatory (LIGO) is $28.50 million, a decrease of $1.0 million, or 3.4 percent, from the FY 2008 Estimate of $29.50 million.

The Laser Interferometer Gravitational Wave Observatory
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
LIGO	$33.00	$29.50	$28.50	-$1.00	-3.4%

Einstein's theory of general relativity predicts that cataclysmic processes involving extremely dense objects in the universe will produce gravitational radiation. Detection of these gravitational waves is of great importance for both fundamental physics and astrophysics. 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; Hanford has a second interferometer in the same housing. The interferometers are used to measure minute changes in the distances between test masses 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 type of source is on the order of one part in 10^{21}, meaning that the expected change in the apparent 4-km length is only on the order of 4×10^{-18} or about 1/1000th the size of a proton. The 4-km length for LIGO, by far 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.

LIGO's current and projected operations and maintenance requests for FYs 2008 through 2012 are less than the FY 2007 Current Plan since some employees and resources will be diverted to the Advanced LIGO (AdvLIGO) Major Research Equipment and Facilities Construction (MREFC) account project, requested as a new start in FY 2008. LIGO operations will, however, continue to analyze data taken during the current and earlier runs and will plan for and conduct future scientific runs until the scheduled shutdown of the detectors in FYs 2010-2011.

Total Obligations for LIGO
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	ESTIMATES FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Operations and Maintenance	$33.00	$29.50	$28.50	$28.50	$29.00	$31.00	$33.00	$36.00

Of the four known fundamental forces of nature – electromagnetic, weak, strong, and gravitational – the gravitational force is the most enigmatic. It is by far the weakest, yet it holds the universe together, ignites the fusion reaction in stars, and curves space in black holes so severely that light is trapped. Furthermore, even though the universe is believed to be filled with gravitational waves, not only from a host of cataclysmic cosmic phenomena but from the Big Bang itself, we have never detected a gravitational wave nor measured its waveform. The principal scientific goals of LIGO are to detect gravitational waves for the first time and to develop this capability into a new window on the universe, a window through which we can observe phenomena such as the inspiral and coalescence of neutron stars

in binary orbit, black hole collisions, unstable dynamics of newborn neutron stars, supernovae, stochastic background from the early universe, and a host of more exotic or unanticipated processes.

LIGO has been a significant source of highly trained Ph.D. graduates for the country's workforce. The number of graduate students has grown from the beginning of LIGO's science runs in FY 2002 and will continue to do so. In addition, LIGO has a diverse set of educational activities at its different sites, activities that involve a large number of undergraduates (including those from minority-serving institutions), hands-on activities for K-12 classes, teachers at all levels, and informal education and outreach activities for the public. A Visitor Center at the Livingston, LA site, dedicated in November, 2006, is filled with Exploratorium exhibits and is the focal point for augmenting teacher education at Southern University and other student-teacher activities state-wide through the Louisiana Systemic Initiative Program, originally funded by NSF.

Substantial connections with industry have been required for the state-of-the-art construction and measurements involved in the LIGO projects. Some have led to new products. Areas of involvement include novel techniques for fabrication of LIGO's vacuum system, seismic isolation techniques, ultrastable laser development (new product introduced), development of new ultra-fine optics polishing techniques, and optical inspection equipment (new product). LIGO has recently cooperated with the Defense Intelligence Agency on research on LIGO interferometers as impulse seismic event detectors.

A recent image of the LIGO Science Education Center in Louisiana. *Credit: LIGO*

In 1997 LIGO founded the LIGO Scientific Collaboration (LSC) to organize the major international groups doing research that was supportive of LIGO. The LSC now has more than 40 collaborating institutions with over 500 participating scientists. A Memorandum of Understanding (MOU) between the LIGO Laboratory and each institution determines the role and membership responsibilities of each participating institution. The LSC plays a major role in many aspects of the LIGO effort including: 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 estimated to be about $5.5 million.

LIGO concluded its mission-defining scientific run (S5), in which a year's accumulation of data is being taken with all three interferometers operating in coincidence, in October, 2007. These data were taken at a detector sensitivity in excess of the defined goal sensitivity outlined in the design specifications. Science runs planned to begin in 2009 will test technologies that will become part of AdvLIGO; the detector sensitivity will be at least twice that during the current S5 run.

LIGO's operations during the AdvLIGO construction era will concentrate on:

- Planning for and operation of "enhanced" initial LIGO in FYs 2008-2011;
- Research and Development to reduce risk for the AdvLIGO project, to enhance performance post-construction and to enable future enhancements.
- Data analysis and other science activities by staff of the LIGO Laboratory.
- Education and Outreach activities; and

- Ramp-up of AdvLIGO commissioning activities.

For more information on AdvLIGO, see the MREFC chapter.

Facility Report:

Management and Oversight:

- NSF Structure: NSF oversight is coordinated internally by the LIGO Program Director in the Division of Physics, who also participates in the Physics Division AdvLIGO Project Advisory Team, comprising staff from the Office of General Counsel, the Office of Legislative and Public Affairs, the Office of Budget, Finance and Award Management, including the Deputy Director for Large Facility Projects, and the Office of International Science and Engineering.

- External Structure: LIGO is sponsored by NSF and managed by Caltech under a cooperative agreement. The management plan specifies significant involvement by the user community, represented by the LIGO Scientific Collaboration (LSC), and collaboration with the other major gravitational-wave detector activities in Japan, Europe, and Australia. External peer-review committees organized by the NSF help provide oversight through an annual review.

- Reviews conducted:
  - Advanced LIGO Baseline Review, May-June 2006
  - LIGO Annual Review, November 2006
  - Advanced LIGO Baseline Update Review, June 2007
  - LIGO Annual Review and LIGO FY 2009-2013 Operations Proposal Review, November 2007

Renewal/Recompetition/Termination:

LIGO's current operations cooperative agreement expires at the end of FY 2008. LIGO has submitted a proposal for continued operations, and a review of that proposal was conducted in November 2007. An Action Item for continued support of LIGO operations will be submitted to the National Science Board in FY 2008 for a FY 2009 start.

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, please see the MREFC chapter in this document.

National High Magnetic Field Laboratory — $31,500,000

The FY 2009 Budget Request for the National High Magnetic Field Laboratory (NHMFL) is $31.50 million, an increase of $5.0 million, or 18.9 percent, over the FY 2008 Estimate of $26.50 million.

The National High Magnetic Field Laboratory
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
NHMFL	$26.55	$26.50	$31.50	$5.00	18.9%

The NHMFL is operated by Florida State University (FSU), the University of Florida (UF), and Los Alamos National Laboratory (LANL). The Laboratory develops and operates high magnetic field facilities that scientists and engineers use for research in physics, biology, bioengineering, chemistry, geochemistry, biochemistry, materials science, medicine, and engineering. It is the world's premier high magnetic field laboratory with a comprehensive assortment of high-performing magnet systems. Many of the unique magnet systems were designed, developed, and built by the magnet engineering and design team at the NHMFL in collaboration with industry. The facilities are available to all qualified scientists and engineers through a peer-review proposal process. The additional funding requested in FY 2009 will support magnet development, new instrumentation, planned facility upgrades, and support of in-house high impact research and development.

Total Obligations for the NHMFL
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	ESTIMATES FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Operations and Maintenance	$26.55	$26.50	$31.50	$33.00	$34.00	$34.00	$35.00	$35.50

Estimates from FY 2010-12 reflect the anticipated budget schedule based on the NSB approved 5-year (2008-2012) renewal award (August 8, 2007, NSB-07-78). Estimates for FY 2013-14 are dependent on the outcome of a renewal or recompetition in FY 2012.

The principal scientific goals of NHMFL are to provide the highest magnetic fields, state-of-the-art instrumentation, and support services for scientific research conducted by users from a wide range of disciplines, including all areas of science and engineering. In addition, the laboratory is an internationally recognized leader in state of the art magnet design, development, and construction. The Magnet Science and Technology (MS&T) Division of the NHMFL has broad responsibility to develop high field magnets and conducting and superconducting materials for future generation magnet wires in response to national needs. MS&T cooperates with industry and other international magnet laboratories on a variety of technology projects. These projects cover the range of analysis, design, materials, component development and testing, coil fabrication, cryogenics, system integration and testing.

Current magnet development at NHMFL is focusing on design and construction of high field magnets for the Nation's premier neutron and light sources. The laboratory has collaborated with more than 60 private sector companies including American Magnetics, Exxon Mobil Corporation, and Oxford Instruments; national laboratories and federal centers including major national laboratories supported by the Department of Energy such as the Spallation Neutron Source and the Advanced Photon Source.

International collaboration includes magnet development with the Hahn-Meitner Institute in Berlin and the Korea Basic Science Institute.

The NHMFL, with its distinguished faculty and world-class facilities, provides a unique interdisciplinary learning environment. Its annual K-12 outreach efforts engage over 7000 students from Florida and neighboring Georgia in hands-on science activities and tours of the laboratory. The research experiences for teachers and students plant seeds for developing the next generation of scientists, engineers, and science education leaders. In addition the NHMFL conducts a College Outreach-Workforce Initiative (CO-WIN) Program to increase diversity in the NHMFL programs. This has included outreach to approximately 200 undergraduates at Historically Black Colleges and Universities (HCBUs).

Facility Report

Management and Oversight:

- NSF Structure: The NHMFL is supported by the Division of Materials Research and the Division of Chemistry in the Mathematical and Physical Science Directorate. Primary responsibility for NSF administration and oversight of the NHMFL is the responsibility of the National Facilities Program Director in NSF's Division of Materials Research with guidance from an ad hoc working group with representatives from the Division of Chemistry in MPS, the Directorate for Engineering (ENG), and the Directorate for Biological Sciences (BIO). Site visit reviews are conducted annually. Representatives from other federal agencies including the Department of Energy (DOE) and the National Institutes of Health (NIH) are invited to participate as observers at the site visit reviews.

- External Structure: The NHMFL is operated for the NSF by a consortium of institutions comprised of FSU, UF, and LANL under a cooperative agreement that sets forth the goals and objectives of the NHMFL. FSU, as the signatory of the cooperative agreement, has the responsibility for establishing and maintaining appropriate administrative and financial oversight and for ensuring that the operations of the laboratory are of high quality and consistent with the broad objectives of the cooperative agreement. The principal investigator serves as the director of the NHMFL. Four senior faculty members serve as co-principal investigators.

  The NHMFL director receives guidance and recommendations from an External Advisory Committee, the NHMFL Executive Committee, NHMFL staff, the participating institutions, and the Users' Committee.

- Reviews: NSF conducts annual reviews using external reviewers. The reviews assess the user programs (access and service), the in-house research programs, the long-term plans of the NHMFL to contribute significant research developments both nationally and internationally, and the operations, maintenance and new development of its facilities. The annual reviews also assess the status of education training and outreach, the efficiency of operations and management of the facility, and the diversity plan. Specific reviews include:
  - Annual Review by program panel, March 2, 2005
  - Standard Award Monitoring Visit from DGA Annual Schedule, November 15-17, 2005
  - Annual Review by program panel December 4-6, 2005
  - Reviews by NSF Advisory Panel of Future Support for High Magnetic Fields, April 1st, April 21-22, April 23, and April 28, 2005
  - Renewal Review, January 9-11, 2007
  - Business Systems Review, planned, Spring 2008

- Annual Program Review, planned, September 2008

Renewal/Recompetition/Termination:

The current cooperative agreement for the support of NHMFL operations expires on December 31, 2007. A comprehensive renewal review was conducted during FY 2007. On August 8, 2007 the National Science Board approved NSF's recommendation for a 5-year renewal award not to exceed $162 million for 2008-2012. The new cooperative agreement becomes effective on January 1, 2008 and expires on December 31, 2012. This award will allow the NHMFL to increase its user program, continue the development of new magnet systems, and support the strongest aspects of its in-house research proposal, and ensures that the Laboratory will remain the international leader in magnet research operations and development.

National Nanotechnology Infrastructure Network — $13,500,000

The FY 2009 Budget Request for the National Nanotechnology Infrastructure Network (NNIN) is $13.50 million, equal to the FY 2008 Estimate.

National Nanotechnology Infrastructure Network
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimated Amount	Change over FY 2008 Estimated Percent
National Nanotechnology Infrastructure Network	$13.32	$13.50	$13.50	-	0.0%

The National Nanotechnology Infrastructure Network comprises 13 university sites that form an integrated national network of user facilities supporting research and education in nanoscale science, engineering, and technology. The NNIN provides users across the nation with access, both on-site and remotely, to leading-edge tools, instrumentation, and capabilities for fabrication, synthesis, characterization, design, simulation, and integration. The broad scope of NNIN coverage includes areas of physics, chemistry, materials, mechanical systems, geosciences, biology, life sciences, electronics, optics, molecular synthesis, and molecular scale devices, among others.

Total Obligations for NNIN
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	ESTIMATES FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Operations and Maintenance	$13.32	$13.50	$13.50	$14.00	$14.32	$14.65	$14.99	$15.33

NNIN's broad-based national user facilities enable the nation's researchers from academia, small and large industry, and government to pursue transformative research, to seek new discoveries and applications in a broad range of domains of nanoscale science and engineering, and to stimulate technological innovation. The network also develops 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.

NNIN undertakes 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 is 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 seeks 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 shares expertise and perspectives, provides specialized training opportunities, coordinates access to unique instrumentation, and transfers newly developed technologies.

NNIN leverages research strengths of the university to bring them to the external community. The institutions comprising the NNIN have strong underlying internal research programs that provide critical research mass and knowledge base in developing new processes, methodologies, and instrumentation, as

well as providing much of the capital infrastructure. NSF and other agencies independently award research grants to principal investigators who use the NNIN facilities to carry out some aspects of their research projects.

NNIN continues to maintain a strong network-wide Research Experience for Undergraduates (REU) program. In FY 2007, 70 undergraduate students participated in the REU program, with at least 5 REU students at each of 12 sites. Student support was provided through an NSF REU site award, use of NNIN base funds, and industry funds. A REU Convocation was held at the end of the summer in which students from all NNIN sites gathered at one site for a 3-day technical symposium with their peers.

Nanooze, the kids' webzine on Nanotechnology produced by NNIN, was started in 2005 and has articles, interviews, the latest in science discoveries and even games. Content is delivered in a factual but informal style to create a medium friendly to young inquiring minds. *Nanooze* is currently published in English, Spanish and Portuguese and has a world-wide readership. *Credit: NNIN.*

Now in its fourth year of operation, NNIN is focused on eliminating barriers to ensure a large diversity of research ideas and users. The major portion of NSF funds provides for operation and staffing of the user facilities and associated network activities. Funds also provide for acquisition and for in-house development of appropriate instrumentation, tools, and processes to serve the user needs. This year the cumulative number of users for all NNIN sites increased by 9% over the previous reporting year to 4437, which included 3668 academic users (primarily graduate students, as well as undergraduates and postdoctoral associates), 473 small company users, and 210 large company users. It is estimated that over $400 million in research investment nationwide is leveraged by use of NNIN facilities. Most interestingly, many start-ups and small companies have chosen to utilize NNIN facilities as prototyping labs for developing new commercial ideas.

Facility Report:

Management and oversight:

- NSF structure: NSF provides oversight of the NNIN under a cooperative agreement. The program officer for the NNIN activity resides in the Division of Electrical, Communications and Cyber Systems (ECCS) in the Directorate for Engineering (ENG). The program officer coordinates NNIN oversight with the NNIN working group comprised of representatives from all NSF research and education directorates. NNIN is reviewed annually through site reviews held at one of the network sites. These reviews involve an external team of experts selected by NSF staff. In addition to the annual site reviews, semi-annual briefings of NSF staff are held at the NSF attended by the NNIN Network Director, Site Directors, and area Coordinators.

- External structure: 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 Network Director, who is from the lead institution, Cornell University, provides intellectual leadership for the network; is 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 the 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.

- Reviews Conducted:
  - 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.
  - Upcoming reviews: A fourth annual review is planned for mid-2008. This review will serve also to evaluate the NNIN renewal proposal for the period FY 2009-2113.

Renewal/Recompetition/Termination:

As provided in the National Science Board award recommendation, the NNIN cooperative agreement may be renewed once, without recompetition, for an additional 5 years, subject to satisfactory review of performance and availability of funds. The maximum duration of the award is for 10 years. A renewal proposal is expected to be submitted in early 2008 for the five-year period FY 2009-2113.

National Superconducting Cyclotron Laboratory $20,500,000

The FY 2009 Budget Request for the National Superconducting Cyclotron Laboratory (NSCL) is $20.50 million, an increase of $2.0 million, or 10.8 percent, over the FY 2008 Estimate of $18.50 million.

National Superconducting Cyclotron Laboratory
(Dollars in Millions)

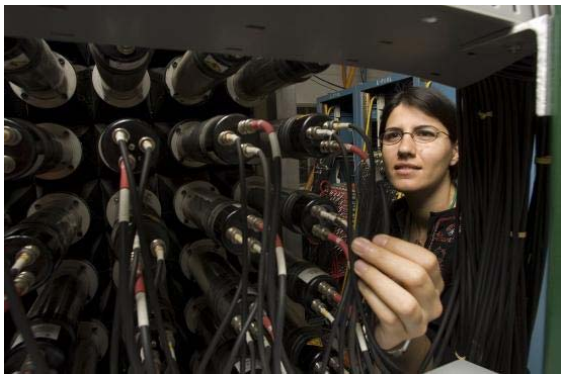
The National Superconducting Cyclotron Laboratory
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
The National Superconducting Cyclotron Laboratory	$18.50	$18.50	$20.50	$2.00	10.8%

The NSCL at Michigan State University (MSU) is a national user facility. With two 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 the NSCL also supports the MSU research program. The $2.0 million increase in FY 2009 includes $1.0 million to compensate for requested funds in FY 2008 that were not appropriated. The full FY 2009 Request will support the increasing costs of maintaining the infrastructure as well as increasing personnel costs.

Total Obligations for the NSCL
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	ESTIMATES FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Operations and Maintenance	$18.50	$18.50	$20.50	$21.00	$21.50	$22.00	$22.50	$23.00



An NSCL research associate adjusts cabling on a detector. *Credit: NSCL.*

NSCL scientists employ a wide 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 recently completed 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 and opening a new window on the cosmos.

Scientists at the 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 level graduate education and post-doctoral research experience. Approximately 10 percent of all doctorates granted in nuclear physics in the United States are based on research at the NSCL. In addition, the site provides research experiences for undergraduate students, as well as training for K-12 teachers.

NSCL occasionally enters into license agreements with industry for cyclotron technology or nuclear electronics. A specific license agreement with Accel Corp. exists for compact cyclotrons based on superconducting technology.

An experimental program using the coupled cyclotron facility is now underway. The FY 2009 requested level of support is consistent with recommendations from an external 2006 science and operations review committee, and will enable near-optimal operations and research at this unique radioactive ion beam facility.

Facility Report:

Management and Oversight:

- NSF Structure: NSF has a Cooperative Agreement with Michigan State University (MSU) for operation of the NSCL. The Laboratory Director is the key named officer, who has the authority to appoint Associate Directors and to designate their responsibilities, notifying NSF of any such changes. NSF oversight is provided through annual site visits by the cognizant program officer of the Physics Division and other staff, accompanied by external experts.

- External Structure: The NSCL is managed by the Laboratory Director and three Associate Directors: one for Nuclear Science, one for Accelerator Research, and one for Operations. The NSCL research program is guided by a Program Advisory Committee consisting 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 opportunities for proposal submission each year. Approximately 5,000 beam hours for experiments are provided each year. There is generally at least a one-year backlog for experiments.

- Reviews:
  - Latest Review: Science and operations review in FY 2006 prior to the renewal of the award beginning in FY 2007.
  - Next Review: Following the extensive review in FY 2006 prior to the renewal of the Cooperative Agreement, annual reviews are planned for FY2008 (to consider the first year of operations) and each year thereafter. The review topics include, but are not limited to science and operations (including management), with emphasis (and choice of external experts) to be determined

Renewal/Recompetition/Termination:

The NSCL is funded through a cooperative agreement that was renewed in FY 2007 and that will expire in FY 2011. NSF anticipates that MSU will submit a renewal proposal in FY 2011. NSF will decide at that time whether to recompete the award, or whether to proceed with merit review of the proposal. Funding for FY2012 and beyond will be determined by the outcome of that process.

Network for Engineering Earthquake Simulation — $23,020,000

The FY 2009 Budget Request for the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES) is $23.02 million, an increase of $850,000, or 3.8 percent, over the FY 2008 Estimate of $22.17 million.

Network for Earthquake Engineering Simulation
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Network for Earthquake Engineering Simulation	$20.74	$22.17	$23.02	$0.85	3.8%

NEES is a national, networked simulation resource of 15 advanced, geographically distributed, shared use 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 U.S., networked together through a high performance Internet2 cyberinfrastructure system. NEES completed construction on September 30, 2004, and opened for user research and education projects on October 1, 2004. NEES is currently operated by the non-profit corporation NEES Consortium, Inc. (NEESinc), headquartered in Davis, California. Through an initial five-year cooperative agreement with NSF (FY 2005 – FY 2009), NEESinc operates the 15 experimental facilities and the NEES cyberinfrastructure center; coordinates education, outreach, and training; and develops national and international partnerships.

Total Obligations for NEES
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	ESTIMATES FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Operations and Maintenance	$20.74	$22.17	$23.02	$23.57	$23.57	$23.60	$24.19	$24.19

NEES' broad-based national research facilities and cyberinfrastructure enables new discovery and knowledge through capabilities to test more comprehensive, complete, and accurate models of how civil infrastructure systems respond to earthquake loading. This enables the design of new methodologies, modeling techniques, and technologies for earthquake 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. NEESinc has developed an education, outreach, and training strategic plan to develop a broad spectrum of education and human resource development activities with special emphasis on non-traditional users and underrepresented groups.

Through the Congressionally mandated National Earthquake Hazards Reduction Program (NEHRP), the Federal Emergency Management Agency (FEMA), the National Institute of Standards and Technology (NIST), the U.S. Geological Survey (USGS), and the NSF support research 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 is leveraging and complementing its capabilities through connections and collaborations with large testing facilities at foreign earthquake-related centers, laboratories, and institutions. NSF and NEESinc have recently developed partnerships to utilize the NEES infrastructure with the 3-D Full-Scale Earthquake Testing Shake Table Facility (E-Defense), built by the Japanese National Research Institute for Earth Science and Disaster Prevention (NIED) and operational in 2005. To facilitate NEES/E-Defense collaboration, in August 2005, NEESinc and NIED signed a Memorandum of Understanding (MOU), and 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 March 2007, researchers from 22 countries convened in Ispra, Italy, for the second World Forum to discuss sharing expertise and coordination in earthquake engineering testing and cyberinfrastructure. NSF is also working with New Zealand, through the University of Aukland, to develop collaborative research in earthquake engineering.

The seven-story, 275-ton reinforced concrete structure tested on the University of California, San Diego NEES shake table demonstrated a less costly seismic design method for residential structures in southern California. *Credit: Professor Jose estrepo, Department of Structural Engineering, UCSD*

Along with direct operations and maintenance support for NEES, NSF provides support for research conducted at NEES experimental facilities through ongoing research and education programs. The NEES cyberinfrastructure also provides a platform for the earthquake engineering community as well as other communities to develop new tools for shared cyberinfrastructure. In addition, NSF has initiated grand challenge, small group, individual investigator, payload, and simulation development research projects that utilize the NEES experimental facilities, data, and computational resources to comprehensively address major research questions in earthquake engineering and seismic hazard mitigation. The annual support for such activities, funded through annual program solicitations and through unsolicited proposals, is estimated to be $12.0 million. These awards support basic research in multi-hazard engineering involving experimental and theoretical simulations at the NEES facilities, addressing important challenges in earthquake and tsunami engineering research.

Facility Report:

Management and oversight:

- NSF structure: NSF provides oversight to NEES operations through a cooperative agreement with NEES Consortium, Inc. NEES operations are reviewed through annual site visits. The NSF program manager for NEES is located in CMMI. The Budget, Finance and Award Management Deputy Director for Large Facility Projects provides advice and assistance.

- External structure: NEES Consortium, Inc., located in Davis, CA, operates the 15 experimental facilities and the NEES cyberinfrastructure center; coordinates education, outreach, and training; and develops national and international partnerships. As a non-profit corporation, NEESinc. operates under its own governance structure and is overseen by a Board of Directors elected from its membership in accordance with its by-laws. Day-to-day operations of NEESinc. are overseen by its

headquarters staff led by an Executive Director. Each of the 15 experimental facilities has an on-site director responsible for local day-to-day equipment management, operations, and interface with NEESinc., other NEES facilities, users, and the NEES cyberinfrastructure center for network coordination. The NEES cyberinfrastructure center maintains the telepresence, data, collaborative, simulation, and other related services for the entire NEES network.

- Reviews:
  - Management reviews: NSF BFA Business Systems Review – May 2006
  - Mid-award reviews NSF Annual Review - June 2005, April 2006, and July 2007
  - Upcoming reviews: NSF Annual Review/Renewal/Recompetition Review, July 2008

Renewal/Recompetition/Termination:

NEESinc operates under a five-year cooperative agreement, with annual funding based upon satisfactory progress and availability of funding; renewal review conducted in year four (July 2008) to determine if renewal beyond the initial five-year period is warranted.

Polar Facilities And Logistics — $353,020,000

The FY 2009 Budget Request for Polar Facilities and Logistics is $353.02 million, an increase of $29.48, or 9.1 percent, over the FY 2008 Estimate of $323.54 million.

Polar Facilities and Logistics
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Polar Facilities	$219.20	$217.84	$241.50	$23.66	10.9%
Polar Logistics	$103.94	$105.70	$111.52	$5.82	5.5%
Total, Polar Facilities and Logistics	$323.14	$323.54	$353.02	$29.48	9.1%

Polar Facilities:

The Operations and Science Support program within the Division of Antarctic Infrastructure and Logistics in the Office of Polar Programs (OPP) provides support for all U.S. research conducted in Antarctica, including that funded by U.S. mission agencies, for year-round work at three U.S. stations, two research ships, and a variety of remote field camps. All life support is provided by NSF, including transportation, facilities, communications, utilities (water and power), and health and safety infrastructure. The U.S. Antarctic Program (USAP) also provides environmental stewardship and maintains the U.S. presence in Antarctica in accordance with U.S. policy.

Total Obligations for Polar Facilities
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	ESTIMATES FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Antarctic Infrastructure & Logistics	$166.24	$160.84	$187.50	$192.38	$197.38	$202.51	$207.77	$213.18
U.S. Coast Guard Icebreaker Support	$52.96	$57.00	$54.00	$54.00	$54.00	$54.00	$54.00	$54.00
Total, Polar Facilities	$219.20	$217.84	$241.50	$246.38	$251.38	$256.51	$261.77	$267.18

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

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

Facility Report:

Management and Oversight:

- NSF Structure: OPP has overall management responsibility for Operations and Science Support. Since FY 2006, NSF has also funded the operation and maintenance of the U.S. Coast Guard's (USCG) three polar icebreakers, the Polar Star, the Healy, and the Polar Sea. Beginning in FY 2009, it has been decided that NSF funds operation and maintenance for only the Polar Sea and the Healy because NSF does not envision current or future use of the Polar Star in support of its mission. The agencies cooperate under a Memorandum of Agreement that includes guidance for planning and scheduling. It sets forth the terms and conditions for reimbursement to the USCG by NSF. NSF and the USCG work together to formulate operations and maintenance plans and associated funding requirements. NSF is responsible for ascertaining the needs of other federal agencies and for securing USCG program plans for accommodating them on a reimbursable funding basis.

- External Structure: The current Antarctic support contract was recompeted and awarded to Raytheon Polar Services Company (RPSC) in FY 2000. There are many separate subcontractors for supplies and technical services.

- Reviews: OPP evaluates the performance of RPSC every year via a Performance Evaluation Committee and an Award Fee Board that includes representatives from OPP and the Office of Budget, Finance, and Award Management (BFA). The Operations and Science Support program in the Division of Antarctic Infrastructure and Logistics also provides oversight of the South Pole Station Modernization (SPSM) project, an activity funded out of the Major Research Equipment and Facilities Construction (MREFC) account since FY 1998. In addition, OPP's performance is reviewed externally by Committees of Visitors and the OPP Advisory Committee (OPP AC).

Current Status:

- All facilities (stations, research vessels, and field camps) are currently operating normally. The relatively poor condition of the USCG polar icebreakers, the Polar Star and the Polar Sea, due to their age and the uncertainty regarding their future availability prompted OPP and the OPP AC to identify and study options for reducing demands on the ship-based logistics system. OPP is implementing several projects as contingencies against a possible failure of that system.

Renewal/Recompetition/Termination:

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. Therefore, NSF will not terminate support for the facilities themselves, such as McMurdo Station or South Pole Station. However, the research emphases at the three stations changes as the scientific forefronts addressed there evolve with time. The current Antarctic support contract was recompeted and awarded to Raytheon Polar Services Company (RPSC) in FY 2000. After a five-month phase-in period, RPSC assumed responsibility for operations in March 2000. The contract's ten-year performance period is segregated into a five-year initial period and a five-year option period. NSF exercised its option to extend the performance period through 2010.

Polar Logistics:

Polar Logistics consists of two activities: the U.S. Antarctic Logistical Support Activities program within the Division of Antarctic Infrastructure and Logistics, and the Research Support and Logistics program within the Arctic Sciences Division.

Total Obligations for Polar Logistics
(Dollars in Millions)

	FY 2007	FY 2008	FY 2009	ESTIMATES				
	Actual	Estimate	Request	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
U.S. Antarctic Logistical Support	$67.52	$67.52	$67.52	$67.52	$67.52	$67.52	$67.52	$67.52
Research Support and Logistics	$36.42	$38.18	$44.00	$45.32	$46.68	$48.08	$49.52	$51.01
Total, Polar Logistics	$103.94	$105.70	$111.52	$112.84	$114.20	$115.60	$117.04	$118.53

The U.S. Antarctic Logistical Support Activities program funds support provided by the U.S. Department of Defense (DoD). The DoD operates as a primary logistical support provider on a cost-reimbursable basis. Major funding elements of DoD support include: military personnel, LC-130 flight operations, maintenance, and facilities support of the 109th Airlift Wing (AW) 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 electronic equipment 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 Division is driven by and responds to science supported by the Division. Funding is provided directly to grantees or to key organizations that provide or manage Arctic research support and logistics. The current contract with CH2M HILL (previously, VECO USA) to provide research support and logistics services for NSF-sponsored activities in the Arctic was recompeted and awarded in January 2005. The contract has an initial term of four years and the possibility of three one-year extensions exercised on the basis of performance. 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. Long-Term Ecological Research observatories linked to similar efforts in Europe and Canada.

Facility Report:

Management and Oversight

- NSF Structure: OPP has overall management responsibility for U.S. Antarctic Logistical Support Activities and Arctic Research Support & Logistics. DoD operates as a primary 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.

- External Structure: There are many separate subcontractors for supplies and technical services.

- Reviews: OPP's performance is externally reviewed by Committees of Visitors and the OPP AC.

Current Status:

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

Renewal/Recompetition/Termination:

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. Therefore, NSF will not terminate support for the facilities themselves, such as McMurdo Station or South Pole Station. However, the research emphases at the three stations changes as the scientific forefronts addressed there evolve with time. Support contracts are recompeted as noted earlier.

National Astronomy and Ionosphere Center $11,500,000

The FY 2009 Budget Request for the National Astronomy and Ionosphere Center (NAIC) is $11.50 million, a decrease of $650,000, or 5.3 percent below the FY 2008 Estimate of $12.15 million.

National Astronomy and Ionosphere Center
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
National Astronomy and Ionosphere Center	$10.46	$12.15	$11.40	-$0.75	-6.2%

The NAIC is a visitor-oriented national research center, supported by NSF and focusing on radio and radar astronomy and atmospheric sciences. NAIC is a Federally Funded Research and Development Center (FFRDC) whose principal observing facility is the world's largest radio/radar telescope, a 305 meter diameter reflector constructed within a karst depression in western Puerto Rico near the town of Arecibo. The facility itself is called the Arecibo Observatory. The NAIC is operated by Cornell University for NSF under a cooperative agreement. NAIC provides telescope users with a wide range of research and observing instrumentation and serves over 250 users annually. The center has a permanent staff of scientists, engineers, and technicians who are available to help visiting investigators with their observation programs.

Total Obligations for NAIC
(Dollars in Millions)

	FY 2007	FY 2008	FY 2009	ESTIMATES				
	Actual	Estimate	Request	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Operations and Maintenance (AST)	10.46	10.45	9.60	8.00	4.00	4.00	4.00	4.00
Operations and Maintenace (ATM)	-	1.70	1.80	2.05	2.50	2.50	2.50	2.50
Total, NAIC	$10.46	$12.15	$11.40	$10.05	$6.50	$6.50	$6.50	$6.50

NAIC is jointly supported by the Division of Astronomy (AST/MPS) and the Division of Atmospheric Sciences (AST/GEO). The Astronomy Senior Review recommended an emphasis on survey work and a reduction in AST funding to $8.0 million for the NAIC by 2010. In response, the managing organization, Cornell University, has modified the operating mode for astronomy observations and limited the observing time for astronomy projects. These changes also resulted in a reduction in force of 30 Full-Time Equivalents (FTEs) in FY 2007. In addition, a substantial reduction in the availability of the S-band planetary radar system is anticipated in FY 2008. The FY 2009 Budget Request reflects a planned ramp down to meet the Senior Review recommendation of $8.0 million of AST support by FY 2010. The 900-ton suspended receiver support platform was sandblasted and repainted during the 2007. The $4.0 million project was required to address issues of safety, and was funded by AST and MPS's Office of Multidisciplinary Activities.

The NAIC was founded to advance the study of basic research in radio astronomy, solar system radar astronomy, and ionospheric physics. NAIC's primary education goal is to support and enhance the education of graduate and undergraduate student researchers. Arecibo hosts a Research Experiences for Undergraduates (REU) site. At Arecibo, graduate students receive training through use of the facility for Ph.D. research. NAIC also sponsors a major outreach program in Puerto Rico via a modern Visitor's

Center, a new Learning Center, and summer workshops for K-12 teachers. In addition NAIC holds, in collaboration with the National Radio Astronomy Observatory (NRAO), a summer school on single-dish radio astronomy techniques.

NAIC currently has partnerships with NRAO, Pennsylvania State University and other universities, and the Angel Ramos Foundation of Puerto Rico (a private organization).

A peer-review telescope allocation committee provides merit-based telescope time but no financial support. NSF does not provide awards targeted specifically for use of Arecibo. Many users are supported through NSF or NASA grants to pursue scientific programs that require use of NAIC.

An image of the Arecibo Radio Telescope in Puerto Rico. The gregorian dome and its suspension structure are visible over the main deflector below. *Credit: Arecibo Observatory/NSF*

Facility Report:

Management and Oversight:

- NSF Structure: Ongoing oversight and assessment is by an assigned NSF program director in AST and in consultation with community representatives. The program director makes use of detailed annual program plans, long range plans, quarterly reports (technical and financial) and annual reports that are submitted to NSF by Cornell as well as attending Cornell governance committees. AST program managers work closely with other offices at NSF, particularly the Division of Acquisition and Cooperative Support, the Office of General Counsel, and the Large Facilities Project Office to address issues as they arise.

- External Structure: Management is via a cooperative agreement with Cornell University. Cornell provides management and oversight through its own advisory committees and visiting committees. The NAIC Director is resident at Cornell, and reports to the Vice Provost for Research in Physical Sciences and Engineering. The Arecibo Observatory Site Director reports to the NAIC Director.

- Reviews: Management reviews by external review panels are held midway into each 5-year cooperative agreement. The last management review was in March 2007. NAIC underwent a Business Systems Review by the Office of Budget, Finance, and Award Management in FY 2005. In addition, in response to recommendations from the Senior Review, AST is carrying out a review of administrative and operational costs at all its facilities.

Renewal/Recompetition/Termination:

- The current cooperative agreement with Cornell for the management of Arecibo is in effect through March 31, 2010.

- The Senior Review recommended a further reduction in AST funding to $4.0 million per year beginning in 2011. Cornell is in the process of developing a business plan for 2011 and beyond,

seeking other sources of support and examining alternative modes of operation that may reduce operating costs. AST is contracting a study that will provide an estimate of costs for various options, from mothballing to complete removal of the telescope and buildings and return of the site to a natural state. The costs of these options, and the viability of the business plan for continued operation, must be known by the spring of 2009 in order to make a decision about the future of Arecibo that would support development of the FY 2011 Budget Request.

National Center for Atmospheric Research (NCAR) $95,870,000

The FY 2009 Budget Request for the National Center for Atmospheric Research is $95.87 million, an increase of $8.33 million, or 9.5 percent, over the FY 2008 Estimate of $87.54 million.

National Center for Atmospheric Research
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
National Center for Atmospheric Research	$85.12	$87.54	$95.87	$8.33	9.5%

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

The National Center for Atmospheric Research 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. Facilities available to university, NCAR, and other researchers include world-class supercomputing services, research aircraft, which can be equipped with sensors to measure dynamic physical and chemical states of atmospheric phenomena at local, regional, and global scales, airborne and portable ground-based radar systems, atmospheric sounding, and other surface sensing systems are available for atmospheric research. NCAR operates several facilities of the High Altitude Observatory (HAO) that are dedicated to the study of the Sun, solar phenomena, space weather, and the responses of the upper atmosphere to the Sun's output. As an NSF sponsored facility, NCAR is committed to the dissemination of newly discovered knowledge in all the above areas.

Total Obligations for NCAR
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	ESTIMATES FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Operations and Maintenance	$85.12	$87.54	$95.87	$98.27	$100.72	$103.24	$105.82	$108.47

In FY 2009, increased investments at NCAR will focus on issues of societal importance in the areas of atmospheric chemistry, climate, cloud physics and 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 and responding to severe weather occurrences. Example investments are an increased emphasis on preparing input for the next Intergovernmental Panel on Climate Change (IPCC) assessment and research into significantly enhancing our ability to understand and predict changes in hurricane intensity. In addition, investment in the refurbishment of the NSF-owned infrastructure is planned.

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 larger-scale weather; and the examination of human society's impact on and response to global environmental change. 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 to the general public, K-12 schools, teachers and students, undergraduate and graduate institutions, postdoctoral and career scientists and researchers, as well as to policy and decision makers. Professional training courses, innovative and award-winning science education websites, as well as the directed activities of NCAR's Office of Education and Outreach are further examples of how NSF's goal of integrating research and education is attained through NCAR activities.

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.

NCAR will continue to support its broad science and education programs and continue its support of facilities that serve the atmospheric community, specifically supercomputing and observing facilities. These are detailed in the NCAR Program Plan.

The NCAR strategic plan, "NCAR as Integrator, Innovator and Community Builder," was completed in FY 2006. The plan sets outs the mission, core values and strategic goals that guide NCAR science. In working towards these goals, NCAR will seek to support the scientific community in explaining how the Earth system functions and accurately predicting how it is likely to evolve, providing robust, accessible, and well-integrated information services and tools for research, analysis, and education. NCAR also prepares an annual report (www.nar.ucar.edu/), which provides a summary of the full life-cycle of the research, facilities, and educational activities that have taken place in FY 2006.

Facility Report:

Management and Oversight:

- NSF Structure: NSF's Division of Atmospheric Sciences (in GEO) 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 its management.

- External Structure: NCAR is managed by the University Corporation for Atmospheric Research (UCAR), a university-governed and university-serving organization comprising 71 Ph.D. granting academic institutions. UCAR works in partnership with NSF, the university community, and its other research sponsors such as NASA, NOAA, DOE, DOD, EPA, and the FAA wherever such research collaboration enhances NCAR's basic NSF-supported research goals or facilities missions

- Reviews:
  - Management review: March, 2006.

Renewal/Recompetition/Termination:

The cooperative agreement for the management of NCAR is currently being competed. The next agreement will be for the five years beginning in FY 2009. Proposals will be subject to NSF's standard merit review procedures, with expert reviewers who are preeminent researchers and managers.

National Optical Astronomy Observatory and National Solar Observatory $41,830,000

The FY 2009 Budget Request for the National Optical Astronomy Observatory (NOAO) and the National Solar Observatory (NSO) is $41.83 million, an increase of $3.28 million, or 8.5 percent, above the FY 2008 Estimate of $38.55 million.

The National Optical Astronomy Observatory and the National Solar Observatory
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
National Optical Astronomy Observatory and National Solar Observatory	$34.55	$34.55	$36.83	$2.28	6.6%
Telescope System Instrumentation Program	$4.00	$4.00	$5.00	$1.00	25.0%
Adaptive Optics Development Program	$0.73	-	-	-	-
Total	$39.28	$38.55	$41.83	$3.28	8.5%

NOAO was established in 1982 by uniting the 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 astronomy. NOAO also is the gateway for the U.S. astronomical community to the International Gemini Observatory. NSO operates facilities in New Mexico and Arizona as well as a coordinated worldwide network of six telescopes (GONG++) specifically designed to study solar oscillations. NSO makes the world's largest collection of optical and infrared solar telescopes and auxiliary instrumentation available to qualified scientists for observation of the solar photosphere, chromosphere, and corona. NSO also provides routine, synoptic solar data used by many researchers and other agencies. As national facilities, NOAO and NSO telescopes are open to all astronomers regardless of institutional affiliation on the basis of peer-reviewed observing proposals. They serve over 1,000 scientists annually.

Total Obligations for NOAO/NSO
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	ESTIMATES FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Operations and Maintenance	$34.55	$34.55	$36.83	$37.93	$39.07	$40.24	$41.45	$42.70
Telescope System Instrumentation Program	$4.00	$4.00	$5.00	$5.00	$5.00	$5.00	$5.00	$5.00
Adaptive Optics Development Program	$0.73	-	-	-	-	-	-	-
Total, NOAO/NSO	$39.28	$38.55	$41.83	$42.93	$44.07	$45.24	$46.45	$47.70

The FY 2009 Request for base operations for NOAO and NSO is $36.83 million, an increase of $2.28 million over the FY 2008 Estimate. This reflects the transfer of the Advanced Technology Solar Telescope (ATST) engineering design funding of $2.5 million to the Major Research Equipment and Facilities Construction (MREFC) account as well as an increase that will support year two of the facilities' response to the recommendations of the AST Senior Review, which included (i) reinvestment in the infrastructure at KPNO and CTIO and (ii) reductions in several targeted programs. In FY 2009 NOAO plans to begin a multi-year effort to introduce new capabilities to the U.S. community through

investment in new capabilities at KPNO and CTIO and through additional access to non-federal observatories. NOAO manages the national community involvement in the development of potential future infrastructure projects such as the Giant Segmented Mirror Telescope and the Large Synoptic Survey Telescope, both of which are high priority recommendations of the 2000 Decadal Survey conducted by the National Research Council's Astronomy and Astrophysics Survey Committee. NOAO also administers the Telescope System Instrumentation Program (TSIP), funded by NSF, which supports the development and fabrication of instrumentation at private observatories in return for competitively reviewed observing time for the general community. TSIP funding increases by $1.0 million in the FY 2009 Request. NSO is leading the community in design and development of ATST. More information on this project can be found in the MREFC chapter.

The Cerro Tololo Inter-American Observatory 4-meter telescope dome. *Credit: M. Urzua Zuniga/Gemini Observatory.*

NOAO and NSO support basic research in astronomy and solar physics by providing access to forefront, ground-based, observing facilities to the nation's astronomers and solar physicists; by acquiring and archiving astronomical and solar data; by leading development of new astronomical facilities and techniques; by conducting scientific research; and by implementing partnerships with universities, non-federal observatories, and industry to achieve scientific objectives of benefit to the entire nation. Both observatories support U.S. goals in education by promoting public understanding and support of science and by providing education and training programs at all levels. Typically, twenty-five percent of the doctorates awarded annually in astronomy involve use of NOAO/NSO facilities by graduate students. The observatories introduce undergraduate students to scientific research by providing these students stimulating environments where they are exposed to basic astronomical research and related technologies through NSF's Research Experiences for Undergraduate Students (REU) program. NOAO and NSO have diverse education programs, visitor centers, and Web-based information portals.

Thirty-three U.S. member institutions and seven international affiliate members comprise the member institutions of the Association of Universities for Research in Astronomy (AURA), Inc., the management organization for NOAO and NSO. Other partners include the U.S. Air Force Office of Scientific Research, NASA, and industrial vendors. A large number of U.S. universities support their own astronomical facilities at KPNO and CTIO. Development of new telescopes, instrumentation, and sensor techniques is done in partnership with relevant industry through subawards to aerospace, optical fabrication, and information technology companies.

For all NOAO and NSO telescopes, peer-review telescope allocation committees provide merit-based telescope time but no financial support. NSF does not provide awards targeted specifically for use of NOAO and NSO. Many users are supported through NSF or NASA grants to pursue scientific programs that require use of NOAO and NSO.

Facility Report:

Management and Oversight:

- NSF Structure: An NSF program director in the Division of Astronomy (AST) in consultation with community representatives provides ongoing oversight and assessment. The program director makes use of detailed annual program plans, long range plans, quarterly reports (technical and financial) and

annual reports that are submitted to NSF by NOAO and NSO as well as attending the AURA governance committees. AST program managers work closely with other offices at NSF, particularly the Division of Acquisition and Cooperative Support, the Office of General Counsel, and the Large Facilities Project Office to address issues as they arise.

- External Structure: AURA manages the observatories through community-based Observatory Councils, Users' Committees, and Visiting Committees. Separate directors for NOAO and NSO report to the president of AURA.

- Reviews: In addition to reviews held mid-way through all cooperative agreements, NSF conducts periodic reviews of AURA management as needed by external committees. In addition, in response to recommendations from the Senior Review, AST is carrying out a review of administrative and operational costs at all its facilities.

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 current cooperative agreement with AURA for eighteen months, through March 31, 2009. The additional time permits NSF and AURA to incorporate the recommendations of the AST Senior Review into management of NOAO and NSO. A proposal from AURA for a new cooperative agreement for the period FY 2009 – 2013 will be reviewed in FY 2008.

National Radio Astronomy Observatory — $61,560,000

The FY 2009 Budget Request for the National Radio Astronomy Observatory (NRAO) is $61.56 million, an increase of $8.82 million, or 16.7 percent, over the FY 2008 Estimate of $52.74 million.

The National Radio Astronomy Observatory
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
National Radio Astronomy Observatory	$50.75	$52.74	$61.56	$8.82	16.7%

NRAO provides state-of-the-art radio telescope facilities for use by the scientific community. 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. It is a Federally Funded Research and Development Center (FFRDC), which 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. NRAO's headquarters are in Charlottesville, Virginia. NRAO is also the North American implementing organization for the international Atacama Large Millimeter 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.

Total Obligations for NRAO
(Dollars in Millions)

	FY 2007	FY 2008	FY 2009	ESTIMATES				
	Actual	Estimate	Request	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Operations and Maintenance	$41.20	$38.51	$43.61	$43.15	$43.24	$42.89	$44.33	$46.95
ALMA operations	$3.71	$8.22	$11.77	$17.57	$23.50	$30.65	$33.92	$36.41
Implementation of EVLA	$5.84	$6.01	$6.19	$6.38	$1.13	-	-	-
Total, NRAO	$50.75	$52.74	$61.56	$67.10	$67.86	$73.54	$78.25	$83.36

NRAO supports and advances basic research in the astronomical sciences, including understanding the geometry and the matter content of the universe, the formation of galaxies, stars and planets, and the nature of black holes. The primary education goal is to support the development of a scientifically and technically literate society through a comprehensive outreach program in which information about radio astronomy is made available to the public through the world-wide web and news media. Observational facilities are used by graduate students carrying out dissertation research and those on work experience programs and by undergraduate students participating in the Research Experiences for Undergraduates (REU) program. NRAO sites support visitor/education centers and conduct an active educational and public outreach program.

Numerous U.S. universities, NASA, foreign scientific and technical institutes, and industrial vendors are partners. The development of new telescopes, instrumentation, and sensor techniques is completed in partnership with relevant industries through competitive subawards to various large and small aerospace

companies, radio antenna manufacturing firms, and specialized electronics and computer software companies.

A peer-review telescope committee allocates merit-based telescope time but provides no financial support. 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 NRAO.

The Very Large Array (VLA) is undergoing an upgrade of its electronics and communications systems, referred to as Phase I of the Expanded Very Large Array (EVLA), to significantly enhance its capabilities. Work on EVLA began in FY 2001 and is scheduled to be completed in FY 2011. The project is on budget and schedule.

The Very Large Array (VLA) telescope is located about 80 kilometers west of Socorro, New Mexico. The VLA is composed of 27 individual antennas arranged in a "Y" pattern. In their closest configuration (about 1 kilometer wide), the VLA is able to image large portions of the sky. In its largest configuration (about 36 kilometers wide) the VLA is able to hone in on the fine details of astronomical objects. *Credit: NRAO/AUI and Kelly Gatlin, Patricia Smiley*

The NRAO is also engaged in construction of the international ALMA, which in FY 2009 will be entering the 8th year of its eleven year construction phase, funded through the MREFC account. NRAO is the U.S. implementing organization of the ALMA project. Early operations funding for ALMA began in FY 2005 and ramps up steeply in FY 2009. An Operations Plan and a proposal for North American operations were externally reviewed in FY 2007, and a funding profile through FY 2011 was authorized by the National Science Board in December 2007. The operations estimates for FY 2012 and beyond are based on current cost projections. Additional information on the ALMA project is available in the MREFC chapter.

The NRAO budget profile in FY 2011 and following years shows the implementation of the recommendation of the Astronomy Senior Review that operations support for the Very Long Baseline Array (VLBA) be reduced. Details of the budget profile in FY 2010 and beyond are subject to revision as a result of the outcome of cost reviews.

Facility Report:

Management and Oversight:

- NSF Structure: Ongoing oversight and assessment is by an assigned NSF program director in AST and in consultation with community representatives. The program director makes use of detailed annual program plans, long range plans, quarterly reports (technical and financial) and annual reports that are submitted to NSF by NRAO as well as attending the governance committees of the managing organization, Associated Universities, Inc (AUI), in carrying out oversight responsibilities. AST program managers work closely with other offices at NSF, particularly the Division of Acquisition and Cooperative Support, the Office of General Counsel, and the Large Facilities Project Office to address issues as they arise.

- External Structure: Management is through a cooperative agreement with AUI. AUI manages the observatory through community-based oversight and users' committees. The NRAO director reports to the president of AUI.

- Reviews: In addition to reviews held mid-way through all cooperative agreements, NSF conducts periodic reviews of AUI/NRAO management by external committees on an ad hoc basis. In addition, in response to recommendations from the Senior Review, AST is carrying out a review of administrative and operational costs at all its facilities in 2008.

Renewal/Recompetition/Termination:

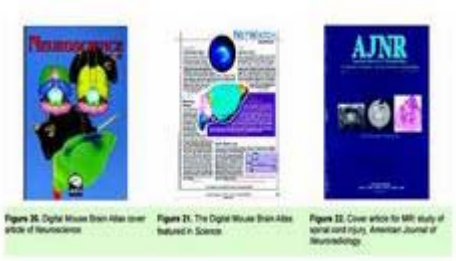
The present cooperative agreement was extended to the end of FY 2009 with approval by the National Science Board in December 2005. A management review of AUI was carried out in early FY 2007. On the basis of this and reviews of ALMA operations, AUI is preparing a renewal proposal for the operation and management of NRAO for the period FY 2009-2013.

RECENT RESEARCH HIGHLIGHTS

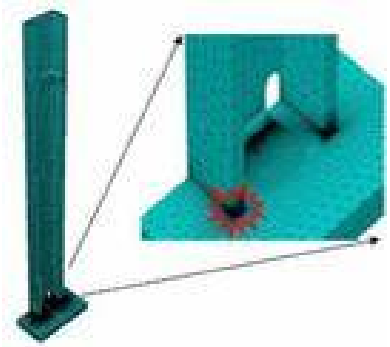
An Air Force C-17 provides supplies to the South Pole Station. *Credit: Photo Courtesy of the United States Antarctic Program.*

► **Air Force C-17 Air Drop at South Pole Station:** During the 2006/2007 season the first operational C-17 airdrop was successfully accomplished over South Pole station. The use of C-17s provides significant additional logistics capabilities for the United States Antarctic Program and insures an emergency capability to deliver supplies during the austral winter. This option can also be applied during the austral summer to deliver up to 90,000 pounds of material to assist in the establishment or re-supply of inland remote science support facilities.

► **A Comprehensive 3-D Digital Atlas Database of the Mouse Brain:** The use of genetically altered mice has revolutionized biomedical research and genetics as numerous genetic diseases can be studied and better understood with a "mouse model" of the disease. But before the effects of the mutations can be fully understood, a benchmark study of a normal mouse was needed. Researchers for the National High Magnetic Field Laboratory working at Brookhaven National Laboratory and the University of Florida successfully used microimaging at 750 MHz in the Advanced Magnetic Resonance Imaging Spectroscopy to make a comprehensive 3-D digital mouse brain atlas of the standard lab mouse. This work was recognized by a cover article in the prestigious American Journal Neuroradiology.



This work was recognized by a cover article in the prestigious American Journal Neuroradiology. *Credit: NHMFL.*

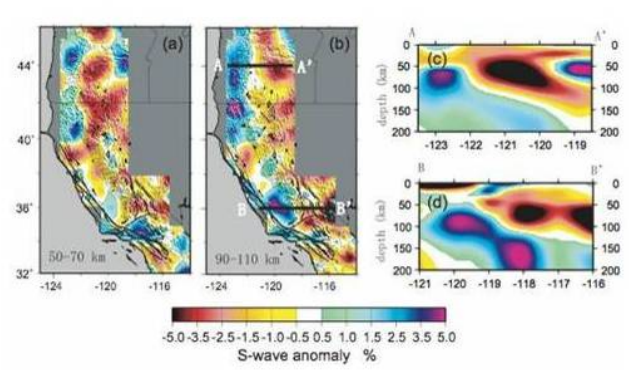


Computer model of damage sustained by a steel column in an earthquake resistant building during testing at NEES facilities. *Credit: Amit Kanvinde, University of California-Davis.*

► **Predicting Earthquake-Induced Fractures in Steel Structures:** Much of the nation's infrastructure consists of steel structures that can fracture during earthquakes. For the first time, researchers using the George E. Brown Jr. Network for Earthquake Engineering Simulation have developed computer models explaining how failure is linked to the growth and shrinkage of microscopic cavities in the steel. In the past, it was only possible to test steel structures experimentally and it wasn't feasible to test large structures. By combining testing and simulation, the researchers developed verified computer models that will allow engineers to design and construct structures that will better withstand earthquakes.

► **South Pole Telescope:** The largest telescope (10m) in Antarctica was successfully constructed and tested at the South Pole during the 100-day 2006/2007 summer season. The observations from this telescope will provide data for new insights to the answers that have been the focus of several national reports, including the 2000 Decadal Report on Astronomy and Astrophysics, the National Research Council's *Connecting Quarks with the Cosmos*, the Office of Science and Technology Policy report *Physics of the Universe*, and most recently the reports of the *Cosmic Microwave Background Task Force* and the *Dark Energy Task Force*.

South Pole telescope. *Credit: Photo courtesy United States Antarctic Program.*



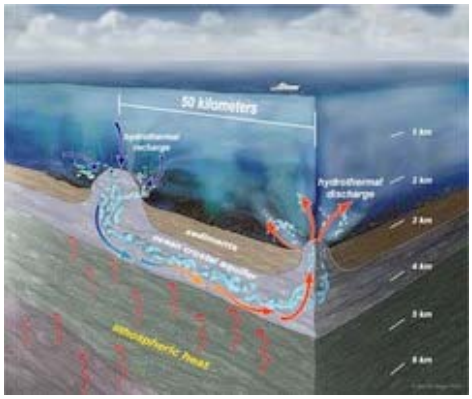
Example model slices from a joint inversion of earthquake and seismic noise. (a) and (b) horizontal slices in the upper mantle at about 60 km and 100 km depth, respectively. (c) and (d) vertical east-west oriented profiles across A-A' the Cascades in central Oregon and B-B' the Great Valley and southern Sierra Nevada Mountains in south-central California. *Credit: Yang, Ritzwoller, Moschetti and Forsyth (2006).*

► **Powerful Techniques to Discover Structure of Earthquakes:** Scientists have developed powerful new analytical methods to create images of structures within the earth's crust. Using data from NSF's EarthScope facility, previously considered to be useless "noise" in seismic records, innovative analysis revealed a wealth of seismic features. Earth scientists anticipate using this new technique to peer into the earth's crust and upper mantle across the conterminous U.S. and Alaska as the EarthScope transportable seismic array rolls across the continent over the next decade.

► **Hilo Students Observe Comet Break-up with Gemini:** A new educational outreach program at NSF's Gemini Observatory in Hawaii is pairing local students with astronomers to do cutting edge astronomy with an 8-meter telescope. The first observations took place in the spring, when three students observed the disintegrating comet 73P/Schwassmann-Wachmann 3 in both visible and infrared light. The students observed the classic head and tail of the comet as well as multiple pieces of the comet's body breaking off. The students will work with the astronomers to do the final, more detailed reduction of the data and determine exactly how the nucleus is breaking apart. They will find out how warm the dust in the tail is and may even be able to tell how much dust is released in the disintegration.

Gemini's Head of Science, Dr. Jean-Rene Roy, looks on as Ken Oyadomari, Keane Nakatsu, Nick Higa, and Gemini astronomer Dr. Scott Fisher (foreground to background) collect comet data at the Gemini North control room in Hilo. *Credit: Gemini Observatory/AURA/NSF.*

► **The Ocean Below the Ocean:** The oceanic crust is the largest fractured water-bearing formation (aquifer) on Earth. The water within this aquifer transports enormous amounts of heat, nutrients, and dissolved minerals across vast distances, influencing volcanic activity and earthquakes, seafloor mineral formation, ocean circulation and currents, and supporting largely unexplored ecosystems that live in an "ocean" below the ocean. There is so much water circulating through the oceanic crust below the seafloor that the entire volume of the ocean is "recycled" about every 200,000-500,000 years. An international team of scientists and graduate students from the U.S.A, Japan, and Europe recently studied this vast aquifer system off the coast of Washington through the NSF-supported Integrated Ocean Drilling Program (IODP). Among results so far, scientists have found that a "hydrothermal siphon" is established, wherein seawater uses volcanic seamounts and permeable crustal rocks to bypass thick layers of impermeable sediment: Seawater is sucked in at one volcanic outcrop and is expelled at another. Thus, the 80,000 to 100,000 seamounts on the seafloor worldwide constitute a vast network of flow channels in the oceanic crust, allowing water, heat, chemicals, and microbiological materials to be exchanged between the ocean and the crust over vast areas. Aside from explaining many crucial processes on Earth, there is even the possibility that similar environments exist on other bodies in our solar system and may be important for harboring life outside of the Earth.



The siphon effect with circulating fluids entering the seafloor at one seamount and exiting from another after traversing the fractured and permeable ocean crust. *Credit: A. Fisher*.

► **Stellar Blast Teaches Astronomers New Lessons About Cosmic Explosions:** **A** powerful thermonuclear explosion on a dense white dwarf star last February gave astronomers their best look yet at the early stages of such explosions, called novae, and of bigger explosions, called supernovae, that are used to measure the expansion history of the Universe. Using the National Science Foundation's Very Long Baseline Array, the Very Large Array and other telescopes, scientists at the University of Manchester's Jodrell Bank Observatory in the United Kingdom saw structure in the blast earlier than in any other stellar explosion. They also saw evidence the explosion may be ejecting material in jets, an observation contrary to theoretical models that assume a spherical shell of ejected material. The researchers agree that their studies show that the explosion is more complex than scientists previously thought such blasts to be.

An artist's rendition of RS Ophiuchi, a symbiotic recurrent nova that went into outburst on 12 February 2006. *Credit: David A. Hardy. (www.astroart.org & PPARC).*

► **Abrupt Ice Retreat Could Produce Ice-Free Arctic Summers by 2040:** An ice-free Arctic could have major implications for weather and climate around the world. Once almost unthinkable, recent research shows that the retreat of Arctic sea ice is likely to rapidly accelerate. To analyze how global warming could affect the ice in coming decades, a team of NSF-supported scientists studied a series of computer simulations run on the Community Climate System Model, one of the world's leading tools for studying climate change. Having first tested the model to show that it closely matched observations of ice cover since 1870, the team simulated Arctic sea ice cover in the future. The results indicated that if greenhouse gases continue to build up in the atmosphere at the current rate, the Arctic's future ice cover will go through periods of relative stability followed by an abrupt retreat so rapid that the Arctic Ocean could become nearly devoid of ice during summertime as early as 2040.

This image, based on simulations produced by the Community Climate System Model, shows the approximate extent of Arctic sea ice in September. The model indicates that this late-summer ice could begin to retreat abruptly within several decades. (Illustrations ©UCAR.) *Credit: UCAR* .

By about 2040 (above), the Arctic may be nearly devoid of sea ice during the late summer unless greenhouse gas emissions are significantly curtailed. (Illustrations ©UCAR) *Credit: UCAR.*