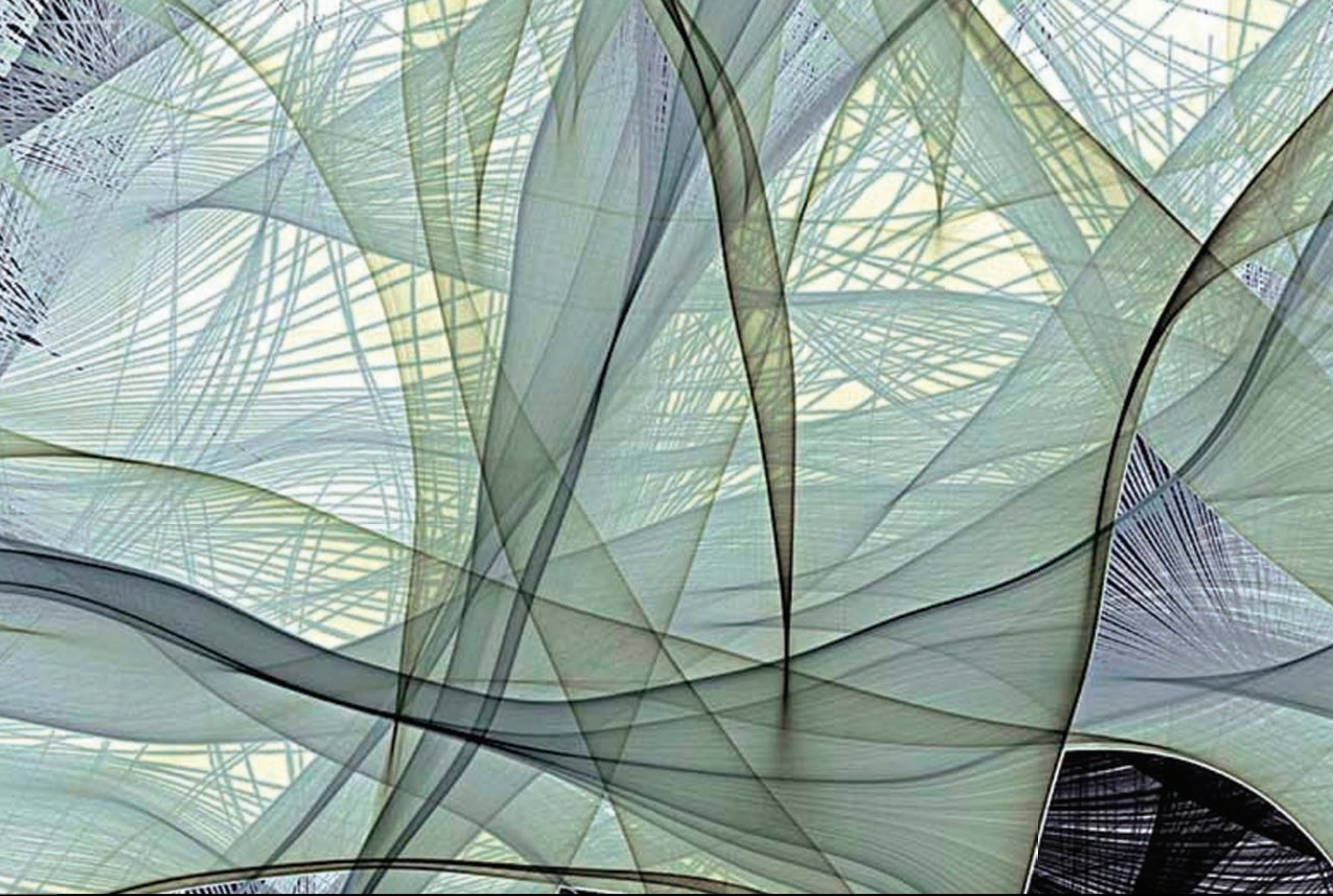

2008 FACILITY PLAN

NATIONAL SCIENCE FOUNDATION

2008 FACILITY PLAN

National Science Foundation

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INTRODUCTION

Across every field of science, mathematics and engineering, opportunities to advance the frontiers of knowledge—from studying the smallest particles of matter to exploring the impact of biological activities and social systems on the global environment—are more promising than ever before. Significant scientific breakthroughs are just over the horizon. To take full advantage of these and other opportunities and maintain U.S. leadership in science and engineering, researchers and educators must have powerful, leading-edge tools and infrastructure. Our scientists, engineers, teachers and students need world-class facilities with the finest precision, the farthest reach and the most comprehensive capabilities.

This report, published each year as a companion to the annual National Science Foundation budget request, provides an update on NSF's investments in major research facilities and infrastructure—investments that keep U.S. science and engineering at the forefront of discovery and innovation and contribute to the nation's competitiveness. Specifically, the *2008 Facility Plan* reports on projects currently included in NSF's Major Research Equipment and Facilities Construction (MREFC) appropriation as well as those operational facilities and major research infrastructure that received new or renewed awards over the past two years.

As with its entire portfolio, NSF's investment in major research infrastructure seeks to transform the frontiers of science and engineering. In addition, this investment helps to train the next generation of scientists and engineers and fund industry to provide the high technology equipment and services necessary for economic growth and innovation. The projects described in this report will advance discovery and learning by:

- Unleashing unprecedented powers of observation on specific phenomena of great scientific interest that will transform individual fields of research; for example, the Advanced Laser Interferometer Gravitational Wave Observatory (AdvLIGO), initiated in FY 2008, will improve by a factor of 1,000 our ability to detect the gravitational waves that produce only infinitesimally tiny distortions in space-time and yet are indications of cataclysmic events occurring throughout the Universe.

- Providing advanced capabilities and state-of-the-art resources for endeavors across multiple fields of science and engineering; for example, the Blue Waters project will make next-generation computational resources available for research and education. Petascale computing will be essential to research in fields as diverse as economics, high-energy physics, meteorology, and neuroscience, as well as other fields that are contributing to the phenomenal growth of—and need to manipulate—data in all its various dimensions.

- Making it possible for scientists to access and conduct research in parts of the world with unique characteristics that will provide answers to major challenges in science and engineering; for example, NSF's ongoing investments in platforms for polar research, notably the South Pole Station Modernization program and the Alaska Region Research Vessel, highlight this commitment to advancing discovery in fields as diverse as climate change, astronomy, basic physics, geology, and marine biology.

- Enabling efforts to collect and provide access to long-term data sets and sustained observational capabilities that uphold U.S. leadership in science and engineering and address national and global priorities; for example, researchers are mining data from the NSF-supported Incorporated Research Institutions for Seismology (IRIS) project to uncover previously unknown geologic processes and structures. IRIS traces its roots to the early 1960s and the first global seismic network for monitoring earthquakes and nuclear testing. Going forward, understanding challenges such as global climate change will require the consistent and long-term collection and integration of massive amounts of data obtained from different kinds of sensors and representing different scales.

Even more impressive than each individual project is the collective impact of the overall investment, which is guided by the research infrastructure goal established in the NSF Strategic Plan, *Investing in America's Future, FY 2006-2011,*[1] to "build the nation's research capability through critical investments in advanced instrumentation, facilities, cyberinfrastructure and experimental tools."

NSF's annual investment in research infrastructure is currently more than $1.8 billion, or roughly 28 percent of NSF's total budget. Over the years, this investment has led to novel research opportunities and fueled technological innovation in fields ranging from biotechnology and medical imaging to nanotechnology and communications. Moreover, NSF's investments have helped to pioneer entirely new approaches to large-scale research endeavors—notably through distributed facilities and networks, such as EarthScope—where capabilities at multiple sites are integrated via leading-edge cyberinfrastructure. This recent expansion of virtual research communities in itself brings potentially transformative impacts to both research and education by creating widely accessible, shared use facilities that allow visualization and integration of phenomena at multiple scales.

The projects described in this plan represent only the latest installment in NSF's long-standing contribution to U.S. leadership in science and engineering infrastructure. These projects—some under construction, some proposed for construction, and others with recently renewed support for operations—will promote training and learning across the various science and engineering fields supported by NSF, generate knowledge that enriches the nation, and enable the United States to maintain its position at the forefront of discovery and innovation.

INDIVIDUAL PROJECT DESCRIPTIONS

In the facility descriptions that follow, we briefly summarize the scientific opportunities and specific facility research objectives that motivate the project's construction or operation. The status of planning, construction,[2] and/or operational activities, and any actions by NSF, are also briefly described.

Wherever possible, NSF attempts to leverage its investments by partnering with other federal agencies, international partners, and other entities to share financial support. In such cases, we describe the status of interagency, international, or industrial partnerships, agreements and co-funding. In addition, we address NSF's role as described in its oversight plan, recent oversight activities, and assessments planned within approximately the next two years, as well as additional project-specific issues. Estimates of the operating and maintenance budget required once each project has achieved full operation are also given.

Within each project description, references are provided for additional information available on Web sites. There is also additional detail on each project in the annual NSF Budget Request to Congress that is available in the MREFC and Facilities chapters of the NSF FY 2009 Budget Request, accessible at http://www.nsf.gov/about/budget/fy2009/. We have not duplicated that information in this report.

MREFC PROJECTS

The individual reports for MREFC projects follow in the order shown in the table on page 6. The table displays MREFC account status using financial data from NSF's FY 2009 Budget Request to Congress and lists all MREFC-funded projects that are under construction or that are pending new starts, along with their anticipated construction budget profiles.

The major horizontal headings within the table reflect the chronological progress of the various projects towards completion:

- Projects in Process of Completion: South Pole Station Modernization (SPSM)
- Projects under Construction: Atacama Large Millimeter Array (ALMA), EarthScope, IceCube, Scientific Ocean Drilling Vessel (SODV)
- FY 2007 New Starts: Alaska Region Research Vessel (ARRV), National Ecological Observatory Network (NEON), Ocean Observatories Initiative (OOI)[3]
- FY 2008 New Start: Advanced Laser Interferometer Gravitational Wave Observatory (AdvLIGO)[3]
- Initial Funding in MREFC FY 2009: Advanced Technology Solar Telescope (ATST)[3]

1 NSF 06-048, National Science Foundation, September 2006. Available on-line at: http://www.nsf.gov/pubs/2006/nsf0648/nsf0648.jsp/.

2 The financial status of each project under construction is reported using Earned Value methodology. The percent complete is the planned cost of all work performed so far and is stated as a proportion of the total budget planned for all work to be performed. The cost variance is the difference between the planned and actual cost of the work performed so far, stated as a fraction of the planned cost. Similarly, the schedule variance is the difference between the cost of the work scheduled to be accomplished and the value of the work actually accomplished, stated as a proportion of the work scheduled. These data were current at the time this document was prepared.

3 Continuation of design and future construction is contingent upon successful project design reviews, continued prioritization by NSF, NSB approval, and the availability of federal funds.

EXISTING FACILITIES AND NEW NON-MREFC INFRASTRUCTURE

NSF funds additional research infrastructure and facilities as well as the operations and maintenance of all NSF-funded facilities through the Research and Related Activities (R&RA) account. While some of the scientific infrastructure constructed using R&RA funds is smaller and qualitatively different than projects constructed using MREFC funds, the story of NSF's major facilities would not be complete without mentioning the larger projects. Therefore, we include new or recently renewed facilities and facility operations awards in this section.

First, we present highlights of six major research infrastructure projects funded through R&RA that were approved for renewal by the National Science Board within the last two years. They are:

- The National Optical Astronomy Observatory (NOAO) and the National Solar Observatory (NSO): the NSB approved a combined award for their operation
- The National Astronomy and Ionosphere Center (NAIC)
- The Incorporated Research Institutes for Research in Seismology (IRIS)
- The National High Magnetic Field Laboratory (NHMFL)
- The Laser Interferometer Gravitational-wave Observatory (LIGO)
- The Large Hadron Collider (LHC) Detectors

The facilities are listed in the order they became operational, from the oldest to the most recent, above and in Table 2 on page 7. The table shows the projected annual budget for operations and maintenance for each project through the duration of the new award. The individual reports for these facilities, provided in the order shown in the table, include brief mentions of some of the major discoveries and advances that the facilities made possible.

Finally, investigations of fundamental scientific challenges and questions require advances in microprocessor speeds, networking, software, visualization, data systems and collaboration platforms—in other words, a new generation of high performance computing resources. Also funded through the R&RA account, three important new computational facilities are highlighted in this section of the report, in the following order:

- The Blue Waters project
- The National Institute for Computational Sciences (NICS)
- The Ranger project

Descriptions for all nine existing facilities and new non-MREFC infrastructure projects, following the same format used to describe the MREFC projects, begin on page 26.

TABLE 1 - MREFC ACCOUNT STATUS

(Dollars in Millions)

	FY 2006 and Prior Years	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2013 Estimate	FY 2014 Estimate
PROJECTS IN PROCESS OF COMPLETION										
South Pole Station Modernization (SPSM)	133.48	6.19	9.10	-						
PROJECTS UNDER CONSTRUCTION										
Atacama Large Millimeter Array (ALMA)	190.97	64.30	102.07	82.25	42.76	13.91	3.00	-		
EarthScope	167.47	25.93	-	-						
IceCube Neutrino Laboratory	178.77	24.38	25.91	11.33	0.95	-				
Scientific Ocean Drilling Vessel (SODV)	72.11	42.83	-	-						
NEW STARTS IN FY 2007										
Alaskan Regional Research Vessel (ARRV)		2.58	42.00	-						
National Ecological Observatory Network (NEON)		-	3.00	-						
Ocean Observatories Initiative (OOI)		-	5.91	-						
NEW STARTS IN FY 2008										
Advanced Laser Interferometer Gravitational Wave Observatory (AdvLIGO)		-	32.75	51.43	46.30	15.21	23.73	15.50	19.78	
INITIAL FUNDING IN MREFC FY 2009										
Advanced Technology Solar Telescope (ATST)		-	-	2.50	-					
MREFC Account Total		$166.21	$220.74	$147.51	$90.01	$29.12	$26.73	$15.50	$19.78	

Totals may not add due to rounding.

TABLE 2 - EXISTING FACILITIES AND NEW NON-MREFC INFRASTRUCTURE AUTHORIZED FOR OPERATION BY THE NATIONAL SCIENCE BOARD WITHIN THE LAST TWO YEARS

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request
Existing Operating Awards			
NOAO and NSO	$39.28	$38.55	$41.83
NAIC	$10.46	$12.15	$11.40
IRIS	$11.77	$11.75	$12.20
NHMFL	$26.55	$26.50	$31.50
LIGO	$33.00	$29.50	$28.50
LHC	$18.00	$18.00	$18.00
Major New Scientific Computing Resources			
Blue Waters[1]	$20.00	$20.00	$38.00
NICS[2]	$38.13	$8.32	$8.86
Ranger Project[2]	$6.90	$6.94	$7.47
Grand Total	$204.09	$171.71	$197.76

[1] Blue Waters award covers acquisitions. O&M funding will be awarded in two years.

[2] NICS and Ranger each have one award that includes both acquisition funds and O&M.

CHAPTER ONE

STATUS REPORTS OF MREFC PROJECTS

PROJECTS IN THE PROCESS OF COMPLETION

SOUTH POLE STATION MODERNIZATION PROJECT (SPSM)

Aerial view of the new Amundsen-Scott South Pole Station, which is designed to house 150 people. It contains science laboratories, a cafeteria, offices, and a gymnasium. The old and new stations stand side by side.

Facility Objectives: The South Pole Station Modernization Project (SPSM) is nearing completion in the construction of a state-of-the-art research station that is larger and more sophisticated than any previous structure built at the bottom of the world. The station's size and capabilities respond to an ever growing requirement for logistical support to carry out the range and quantity of research taking place at the South Pole. Antarctica is the coldest, highest, driest and windiest place on Earth—and the region is among the least hospitable to human life. But these same conditions combine to make the South Pole a unique scientific laboratory for the study of questions as diverse as "What is the origin of the Universe and how did it develop?" and "What is the status of global climate change?" The new station will afford opportunities to explore these and other important questions in areas of science ranging from astrophysics to zoology.

The new Amundsen-Scott South Pole Station, dedicated on January 12, 2008, is an elevated complex with two connected buildings, designed to support 150 people in the summer and 50 people in the winter. Features include a "quiet sector" to support monitoring of the Earth's seismicity, a "clean air sector" for research in atmospheric chemistry, and a "dark sector" to support astronomy and astrophysics. The new station replaces an aging structure built three decades ago and now inadequate in terms of capacity, efficiency and safety. It is the third U.S. station at the Pole since 1956.

The expected lifetime of the modernized station is 25 years, through 2031.

Status: Construction of the new South Pole Station is just over 90 percent complete and is 2 percent under budget and 1 percent behind schedule. All eight wings of the elevated station became operational on or before February 2006. The remaining work includes completing installation of siding on the station and construction of the cargo/warehousing facility. The project schedule was extended to FY 2010 for less urgently needed items to allow redirection of much of the tightly constrained South Pole construction resources to the installation of the IceCube neutrino detector and the South Pole Telescope during 2007 and 2008.

In FY 1997, the construction budget was estimated to be $127.90 million. This was later augmented by about $6 million to extend the construction schedule as a result of weather-induced delays, and to increase the station capacity from 110 to 150 people to accommodate the increased demand by scientists to exploit the unique research opportunities available at the South Pole. Since then, increases in logistical support costs, labor rate adjustments, and allowances to mitigate risks due to weather delays and other variable factors have resulted in a revised estimate at completion of $149.3 million. NSF organized external reviews to validate the revised plan and budget, which was authorized by the NSB in FY 2006.

The FY 2008 budget request provided resources to complete construction activities on the revised schedule. No funds are requested in FY 2009. The remaining work is scheduled for completion in FY 2010

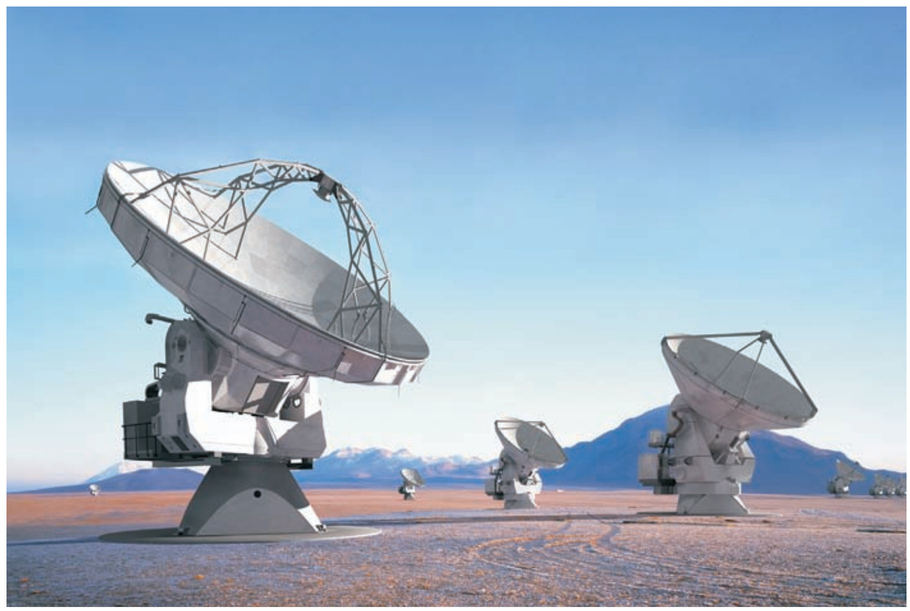
Partnerships: NSF is responsible for managing the U.S. Antarctic Program on behalf of the U.S. government. In doing so, NSF facilitates partnerships between NSF grantees and those supported by other federal agencies and by other nations' governments. For example, NSF support of SPSM makes possible ongoing National Oceanic and Atmospheric Administration (NOAA) research at the South Pole. In another example, SPSM makes possible the multinational IceCube project implemented in partnership with Sweden, Germany and Belgium.

In the 1990s, NSF and the Office of Science and Technology Policy (OSTP) agreed that SPSM should be a U.S. project. This was echoed in a recommendation made in the Report of the U.S. Antarctic Program External Panel: International cooperation in scientific research and logistics support should be encouraged, but permanent facilities and infrastructure at permanent U.S. sites in Antarctica should be provided by and maintained by the United States. The geopolitical significance of the South Pole Station, sitting at the apex of the territorial claims of seven nations, was a major factor in the decision not to seek international partnerships for SPSM construction. An additional factor was that relying on a multinational air support system was believed to increase safety risks.

NSF's Role: NSF's Office of Polar Programs (OPP) has the overall management responsibility for SPSM. Logistics and construction are handled by OPP's prime support contractor, Raytheon Polar Services Company. Architectural and engineering design and construction inspection are provided through a Memorandum of Agreement with Naval Facilities Command and an engineering team of consultants on contract to OPP.

A steady state of operations and maintenance support is anticipated at $15 million per year from the OPP R&RA account—slightly higher than the current annual operational costs. Along with direct operations and maintenance support for South Pole Station, NSF will support science and engineering research through ongoing research and education programs. FY 2009 support for such activities is budgeted at $9.5 million from the OPP R&RA account.

Additional information on SPSM can be found at http://www.nsf.gov/od/opp/support/southp.jsp/.



Artist's concept of the VertexRSI antenna (left foreground) and the AEM antenna (right foreground) superposed on a photo of the ALMA site (Cerro Toco in background).

PROJECTS UNDER CONSTRUCTION

ATACAMA LARGE MILLIMETER ARRAY (ALMA)

Facility Objectives: The Atacama Large Millimeter Array (ALMA) is a giant international observatory under construction in the 5,000-meter high Atacama Desert in northern Chile. ALMA will be the world's most sensitive and highest resolution millimeter-wavelength telescope, providing astronomers with an unprecedented ability to explore the Universe as seen at wavelengths from 3 millimeters to 0.4 millimeters. The high sensitivity and resolution in this range of the spectrum will allow researchers to test novel theories about the origins of stars and planetary systems, the nature of early galaxies, and the evolution of the Universe itself.

When completed, ALMA will comprise an array of 50 high precision 12-meter antennas, plus 16 additional antennas in a component array. With its adjustable configurations—ranging from a compact 150 meters across to as wide as 18 kilometers—ALMA will provide researchers with a "zoom lens" to focus deep in space. The facility combines sub-arc second angular resolution with a sensitivity equivalent to a single antenna nearly 100 meters in diameter. ALMA instrumentation will push gallium arsenide and indium phosphide transistor amplifier technology to high frequencies; it will challenge production of high-density, high-speed integrated circuits for computational uses; and it is expected to stimulate commercial device and communication technologies development.

In addition to its prominent role in explorations of the fundamental questions in astronomy, ALMA also will play a central role in the education and training of U.S. astronomy and engineering students. At least 15 percent of ALMA's approximately 2,000 anticipated yearly users are expected to be students.

The expected operational lifetime of ALMA is at least 30 years.

Status: ALMA construction is currently more than 41 percent complete and is on budget and 4 percent behind schedule. Antenna fabrication is underway, with three antennas from North America and four from Japan delivered to Chile in 2007. Two integrated receiver packages have been produced and are undergoing final testing prior to integration with the antennas in Chile. A major technical milestone was achieved in March 2007 when the signal processing electronics and precision software control capabilities were demonstrated by using two linked prototype antennas to successfully observe astronomical sources. On the ALMA site, technical support buildings and an antenna assembly facility have been completed.

A revised budget of $499 million for the U.S. share of the ALMA construction cost was authorized by the NSB in May 2006, following external review. The facility operations plan was reviewed in 2007 and funding was authorized by the NSB in December 2007. Early science operations are expected to commence in 2010, using a subset of the full antenna array.

Further antennas and receivers will be delivered to the ALMA site for integration and testing in 2008, and test interferometry will commence at the mid-level facility. In 2009, several antennas will be transported to the final, high-altitude site to begin commissioning. Completion of construction is expected in 2012.

Partnerships: Originally referred to as the Millimeter Array (MMA) in the United States, the alliance was named ALMA when North America and Europe became equal partners. Construction was initiated by the United States in FY 2002, and by Europe in FY 2003. Japan joined ALMA as a third major partner in September 2004, and will deliver a number of enhancements to the baseline instrument.

The North American side of the project, consisting of the United States and Canada, is led by Associated Universities, Inc. (AUI) through the National Radio Astronomy Observatory (NRAO). Funding and execution of the project in Europe is carried out through the European Southern Observatory (ESO). Funding of the project in Japan is carried out through the National Institutes of Natural Sciences of Japan, and project execution is the responsibility of the National Astronomical Observatory of Japan.

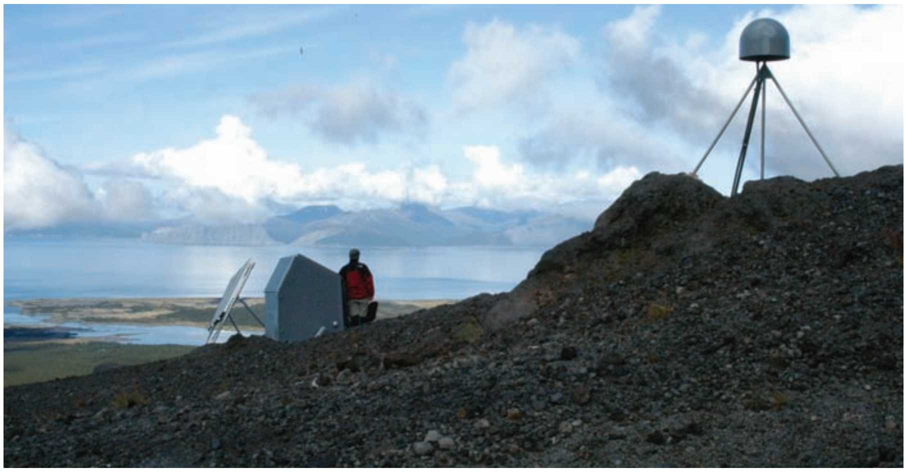
NSF's Role: Program oversight is the responsibility of the ALMA staff associate in the Division of Astronomical Sciences (AST) within NSF's Directorate for Mathematical and Physical Sciences (MPS). Management of the NRAO effort on ALMA is carried out under a cooperative agreement with AUI.

Operations and maintenance (O&M) costs will be provided through the MPS/AST R&RA account. Along with direct O&M support for ALMA, NSF will support research performed at the facility through ongoing research and education programs. The annual support for operations and maintenance is estimated to be about $34 million once the facility reaches full operations in FY 2013.

Additional information on ALMA can be found at http://www.alma.nrao.edu/.

EARTHSCOPE

Facility Objectives: The EarthScope facility is a distributed, continental-scale, multipurpose geophysical-instrument array, with the capability to provide a coherent 3-D image of the lithosphere and deeper Earth. It functions as a unique downward-looking "telescope" and gives geologists unparalleled means to investigate the structure and dynamics of the North American continent. EarthScope data are used by researchers studying earthquakes and seismic hazards, magmatic systems and volcanic hazards, lithospheric dynamics, regional tectonics, and fluids in the crust. The data and data products from EarthScope have already resulted in interesting findings. In one instance, researchers using EarthScope Global Positioning System (GPS) and seismic data reported surprising insights into slow earthquakes (also known as episodic tremor and slip, or ETS) along the Cascadia subduction zone. EarthScope data are freely and openly available via the Internet and are also being used in earthquake response planning, for presentations to researchers and the public, and in university and other educational settings.



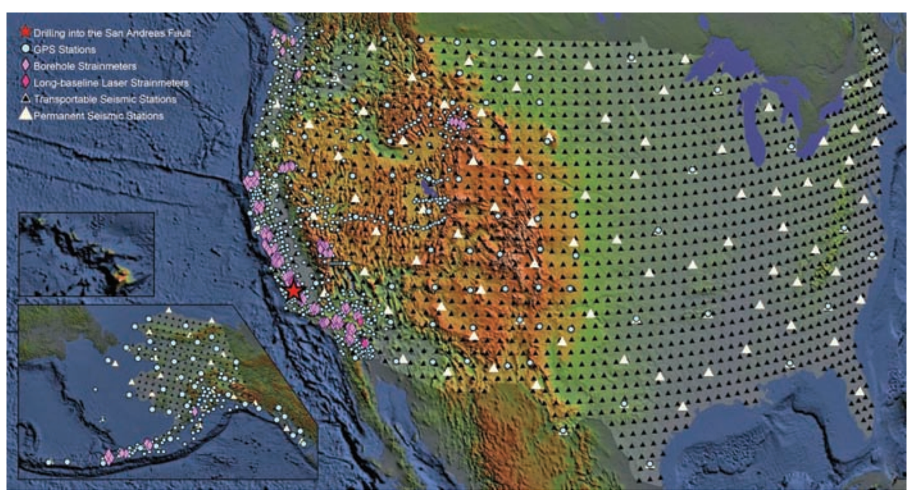
The Plate Boundary Observatory (PBO) component of EarthScope installed, and now operates, permanent, continuously recording Global Positioning System (GPS) stations across the North-American continent to monitor Earth motion. The photo above shows one of several GPS antennas (on the upper right) that were installed on the flanks of the Augustine volcano in the Aleutian Islands. Data acquisition and telemetry equipment are shown on the left.

The EarthScope facility is composed of three major elements—the Plate Boundary Observatory (PBO), a dense array of permanent GPS stations and strainometers in the western United States for recording deformation in and around earthquake-prone regions; the San Andreas Fault Observatory at Depth (SAFOD), a heavily instrumented drill hole that crosses the fault and will provide records of conditions within the seismogenic zone; and the USArray, a combination of portable and permanent seismograph stations that will provide a comprehensive network of sensors to explore seismic activity.

EarthScope also has an education focus, engaging a wide variety of our nation's students in geosciences discovery through the use of data and technology in real time or retrospectively through integrated research and education.

The expected operational lifetime of EarthScope is 15 years.

Status: EarthScope is more than 80 percent complete, and is 3 percent under budget and 5 percent behind schedule. The PBO has installed more than 700 permanent geodetic stations. PBO instrumentation has recorded two volcanic eruptive sequences, one in Cascadia



This map shows the complete EarthScope footprint. About 1,600 of the transportable sites (moving west to east) and all 2,400 campaign stations will continue to be deployed after the conclusion of the MREFC project. Locations of the stations will be determined through the annual proposal review process. Many of these sites likely will change annually.

and one in the Aleutians, and three "slow earthquake" sequences in Cascadia. The first 400 seismic stations of the USArray are deployed and have begun to roll across the continent as facility operations ramp up. Over 3,000 Earth scientists and student researchers are expected to use the facility annually.

Approximately 40 meters of core material (weighing more than one ton) was collected from San Andreas Fault traces in the summer of 2007. Intact lengths of core were retrieved from two different actively creeping traces and in the vicinity of small earthquake nucleation. Rock, fluid and gas samples are being used in scientific investigations in the United States and Europe.

Construction and installation activity is expected to be complete in FY 2008

Partnerships: The U.S. Geological Survey (USGS), the National Aeronautics and Space Administration (NASA), the U.S. Department of Energy (DOE) and the International Continental Scientific Drilling Programme are funding partners; and USGS and NASA are operating partners. Future EarthScope partners may also include state and local governments, geological and engineering firms, and Canadian and Mexican agencies. Geotechnical and engineering firms directly use EarthScope data and models. Instrumentation firms collaborate on development of state-of-the-art seismic systems, down-hole instrumentation, and high-precision GPS antenna designs.

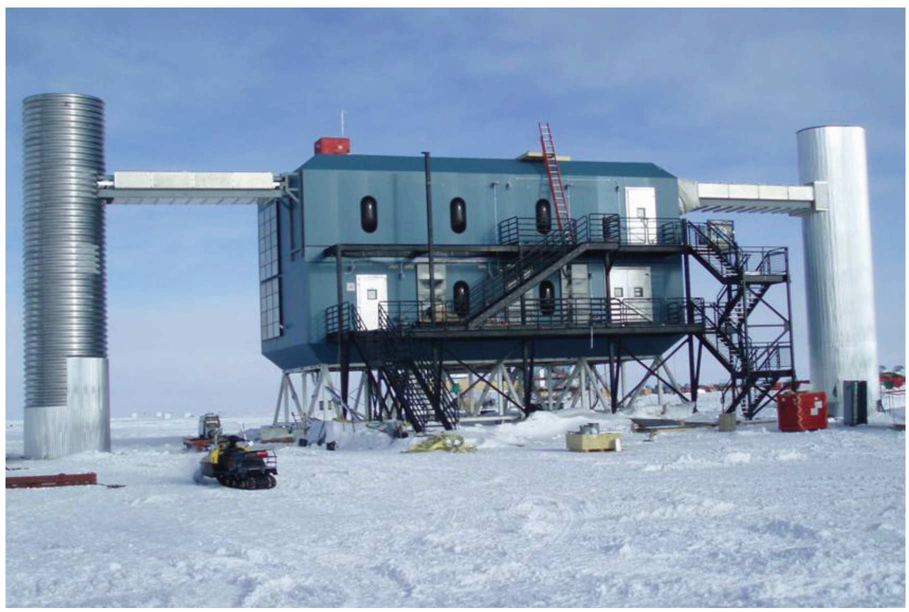
NSF's Role: Programmatic oversight is the responsibility of the EarthScope program director, located in the Earth Sciences Division (EAR) in the Directorate for Geosciences (GEO). Site visits, annual reviews, and regular consultations with external advisory committees are conducted to ensure coordination of facility construction and operation, science, education and outreach, and information technology efforts.

Conceptual planning for EarthScope developed over the past decade. NSF funded planning, design and the implementation over a five-year period of acquisition, facility construction and commissioning beginning in FY 2003. While the final obligation of funds occurred in FY 2007, U.S.-funded construction activities are scheduled to continue through 2008, with project completion and full operation beginning in late 2008. NSF support for annual operations and maintenance is estimated at $24 million through the GEO/EAR R&RA account. NSF is also supporting ongoing research and education programs.

Additional information on EarthScope can be found at http://www.earthscope.gov and http://www.earthscope.org.

ICECUBE NEUTRINO OBSERVATORY

Facility Objectives: IceCube, under construction deep in the clear ice at the South Pole, will be the world's first high-energy neutrino observatory. The facility represents a new window on the universe that will enable researchers to track neutrinos, nearly massless particles created by exotic deep-space events such as supernovae (the death explosions of large stars). IceCube will be a source of unique data on: the engines that power active galactic nuclei, the origin of high-energy cosmic rays, the nature of gamma ray bursters, the activities surrounding super-massive black holes, and more.[3] IceCube will record the energy and arrival direction of high-energy



IceCube Laboratory at the South Pole Station. The large towers contain signal cables from strings of Digital Optical Modules frozen into the ice extending down 2,450 meters below the surface.

3 See the National Academies reports: *Connecting Quarks with the Cosmos—Eleven Science Questions for the New Century*; and *Neutrinos and Beyond—New Windows on Nature.*

View of signal cables from strings of Digital Optical Modules extending down into the ice. Elusive particles, called neutrinos, will be detected arriving from distant astrophysical sources and carrying information about those sources, just as rays of light reveal objects to conventional telescopes.

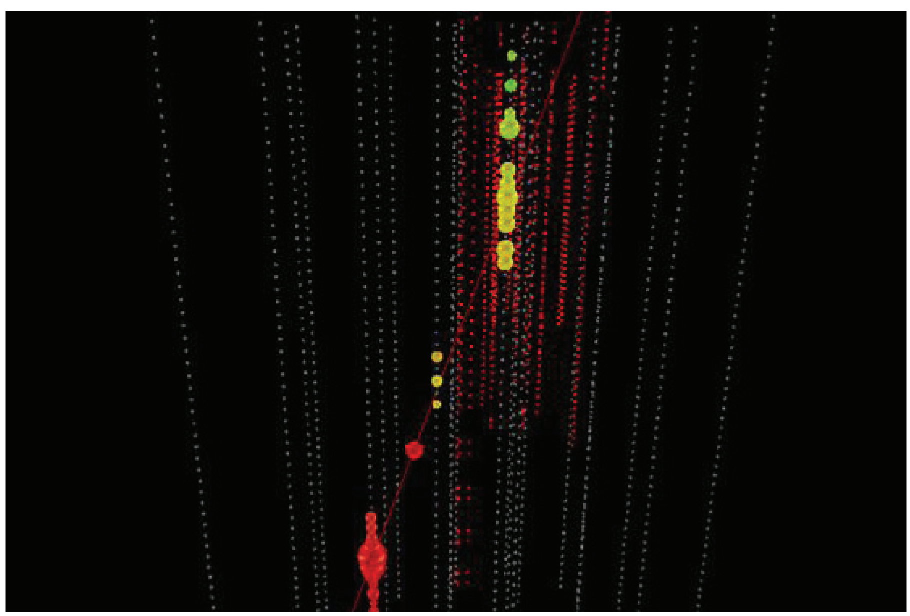
neutrinos ranging in energy from 100 GeV (10^{11} electron Volts [eV]) to 10 PeV (10^{16} eV), with detection sensitivity that extends to 10^{18} eV.

One cubic kilometer of ice is being instrumented with photomultiplier (PM) tubes to detect charged reaction products from high-energy neutrino interactions in the ice within or near the fiducial volume (the sensitive volume for detection). An array of Digital Optical Modules (DOMs), each containing a PM and associated electronics, will be positioned uniformly from 1.45 km to 2.45 km beneath the surface of the South Pole ice cap in highly transparent, bubble-free ice. IceCube will be comprised of 70 strings of DOMs and 140 surface cosmic ray air shower detector modules upon completion.

The expected operational lifetime of IceCube is 25 years.

Status: IceCube is more than 80 percent complete and is within 1 percent of its planned budget and schedule for completion in 2011. A significant portion of the overall project is represented by the specialized hot water drill and the large amount of support equipment that have been designed, built, tested and deployed to the South Pole. Additionally, more than 2,600 DOMs have been produced and tested, and 35 of the 70 planned 60-DOM strings have been deployed deep within the Antarctic ice, including 18 new ones deployed in the current 2007/2008 summer season at the South Pole, which raises the total number of strings to 40 of the 70 that are planned, and 80 of the 140 planned surface modules. If project cost performance remains good, up to 10 strings and 20 surface modules may be added to the project scope.

Custom data acquisition and analysis hardware and software have been developed and are now being used to collect and study the signals coming from the deployed DOMs. With substantial functionality of IceCube in place, limited operations and early science began in May 2007 and will continue as DOM strings are added in the current and subsequent seasons. Construction activities are scheduled to continue through 2011.



This image is a computer reconstruction of a neutrino event recorded in the partially completed IceCube detector in 2007. A neutrino, which entered the Earth somewhere in the northern hemisphere, emerged upward into the Antarctic ice, where it converted into a muon. Light from the muon's traversal was detected by individual DOMs, and information about that detection is graphically displayed in the image above. Each of the individual DOMs are shown as dots, and the colors of the dots indicate when they detected the muon's traversal; red signals indicate earlier times, and yellow and green are progressively later. The diagonal red line shows the trajectory of the muon through the ice.

Partnerships: NSF provides funding to the University of Wisconsin, which leads construction of IceCube. The project is an international partnership with construction co-funding from Belgium, Germany and Sweden, which provide $34.56 million of the total project cost of $276.63 million. The initial total project cost, baselined by NSF in 2004, was $271.77 million. The increase since the baseline reflects real and revalued increases in the foreign partner contributions. NSF funding remains at the initial $242.07 million.

At the April 2006 meeting of IceCube's International Oversight and Finance Group (IOFG), a pro rata cost-sharing plan was developed to jointly support operations, and this plan has been implemented.

NSF's Role: Programmatic oversight of IceCube construction is the responsibility of the program official in MPS acting on behalf of OPP. Following project baseline in 2004, comprehensive annual external progress reviews were held in May 2005, 2006 and 2007, and will be held each subsequent spring throughout construction. Annual external reviews are interspersed with monthly progress reports and quarterly reports, site visits, weekly teleconferences and frequent internal NSF project oversight and management meetings.

NSF conducted a final review of IceCube operations in the spring of 2007 and the award was put in place in September 2007. NSF support for IceCube operations and maintenance will ramp up to $4.3 million per year in FY 2010, which is the anticipated steady state support level. The latter amount will be matched on a pro rata basis by the foreign partners. Operations will be reviewed annually, as construction is now, and the U.S. part of the O&M budget will be shared equally between the R&RA accounts of OPP and the Division of Physics (PHY) in MPS. Support for U.S. research, education and outreach is estimated to reach a steady state level of $4 million per year in FY 2010 and will be shared equally between the same accounts.

Additional information on IceCube can be found at http://www.icecube.wisc.edu/.

SCIENTIFIC OCEAN DRILLING VESSEL (SODV)

Facility Objectives: The Scientific Ocean Drilling Vessel (SODV) project will refurbish the JOIDES Resolution, the pioneering scientific ocean drilling vessel. The next-generation research ship will support the recovery of sediment and crustal rock from the seafloor; the placing of observatories in drill holes to study the deep biosphere; the study of fluid flow in sediments and the crust; and long-term efforts of the international ocean drilling program to investigate solid Earth cycles, geodynamics, and the processes contributing to and affecting environmental change. During its 20 years of service, JOIDES Resolution expeditions produced significant contributions and discoveries, including the first recovery of igneous rocks (known as gabbros) from intact ocean crust, discovery of the deepest-living microbes on Earth, and the discovery of "frozen" natural gas at unexpectedly shallow depths below the seafloor. Core samples brought up during research expeditions have helped scientists validate the theory of plate tectonics, provided extensive information about Earth's past climate, and recovered evidence of the catastrophic asteroid impact that is believed to have wiped out the dinosaurs 65 million years ago.

The new vessel, which promises to improve the quality and rate of core samples brought

The JOIDES Resolution (Scientific Ocean Drilling Vessel) is undergoing refit work while in drydock at Jurong Shipyard in Singapore.

up from the deep, will have at least a 50 percent increase in laboratory space, allowing for a greater variety of instrumentation to analyze cores samples while at sea. It will also include an enhanced drilling instrumentation system, a sub-sea camera system with improved handling, and a new drill string with upgraded drilling tools. Changes to the ship's hull and machinery will improve fuel efficiency and increase transit speed, allowing for more time "on station." The retrofit will also update safety and environmental systems and numerous service life extension features that will enable the vessel to conduct year-round scientific drilling in nearly all ocean environments, subject to limitations regarding minimum water depth and surface ice coverage. The new ship will be ready for science expeditions in mid-2008. The SODV project scope was determined by the U.S. Science Advisory Committee for scientific ocean drilling and coordinated with the scientific community.

The refit of the SODV will extend its anticipated operational lifetime for at least 15 years.

Status: SODV is more than 75 percent complete, and is 1 percent under budget and 4 percent behind the current schedule. However, the current schedule will deliver the vessel for operation at least one-half year later than initially planned, and with technical capabilities that were scaled back from the original plan to fit within the available budget. These measures were necessitated by the enormous worldwide demand for drilling equipment and shipyard resources, and the consequent price escalations that occurred in parallel with planning and construction. The contract for conversion of the drilling vessel JOIDES Resolution commenced in April 2007. Extensive vessel refit activities are well underway at the shipyard, with on-site supervision provided by the drillship owner and the awardee. Dry-docking work has been completed, most of the drilling equipment has been reconditioned, and new laboratory, quarters, and navigation bridge superstructure modules have been fabricated and installed. Finish-out of these areas is now underway.

Science systems design, acquisition, testing and integration are progressing under the stewardship of the Integrated Ocean Drilling Program (IODP) System Integration Contractor (an awardee alliance of the Consortium for Ocean Leadership, Texas A&M Research Foundation and Lamont-Doherty Earth Observatory).

Although the order of drilling projects is subject to revision, near-term scheduling includes: (a) two expeditions to conduct a drilling transect of 6 sites across the equatorial Pacific, with at least three holes at each site designed to recover a continuous Cenozoic record of the equatorial Pacific at successive crustal ages on the Pacific plate; and (b) one expedition in the Bering Sea, to core three holes at each of seven sites to study oscillated climate variation in the last 5 million years as related to Earth's glacial and interglacial periods.

Scientific operation is currently projected to begin in May 2008.

Partnerships: The IODP is co-led by NSF and the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan. MEXT will provide the CHIKYU, a heavy (riser) drillship for deep drilling objectives of the programs. It commenced operations under the auspices of the IODP during the latter part of 2007. NSF will provide the SODV, a light (riserless) drillship offering science support services for high-resolution studies of environmental and climate change, observation activities, and investigation of the deep biosphere. The European Consortium for Ocean Research Drilling, consisting of 17 European countries, is a Contributing Member of IODP. The People's Republic of China Ministry of Science and Technology (MOST) and the Interim Asian Consortium, represented by the Korea Institute of Geoscience and Mineral Resources (KIGAM), also participate as Associate Members of IODP.

NSF's Role: Programmatic oversight is the responsibility of the SODV program officer within the Ocean Sciences (OCE) Division in GEO, assisted by Ocean Drilling Program staff. Internal and external reviews are regularly conducted in addition to site visits, monthly reporting, weekly updates and NSF participation in bi-monthly on-site progress reviews. The SODV Project Advisory Committee has maintained close user community contact during the execution phase of the project.

In FY 2009, GEO/OCE will provide about $52 million from the R&RA account to directly support operations and maintenance for the IODP. In addition, NSF will support ongoing research and education programs at a level of $11million through the GEO/OCE R&RA account.

Additional information on SODV can be found at http://www.oceanleadership.org/.

NEW STARTS IN FY 2007

ALASKA REGION RESEARCH VESSEL (ARRV)

The Alaska Region Research Vessel (ARRV), which will be 236 feet in length, will replace the small, aging R/V Alpha Helix. The ice-strengthened ARRV would operate in the challenging seasonal ice-covered Alaskan waters, expanding current capabilities in the region.

Facility Objectives: The Alaska Region Research Vessel (ARRV) would be a multipurpose research ship with the potential to dramatically improve access to Arctic waters. It is designed to operate in seasonal sea ice and open ocean regions near Alaska—including the Chukchi, Beaufort, and Bering Seas, Gulf of Alaska, Prince William Sound and coastal Southeast Alaska—and have an operating year of as long as 300 days. Satellite observations have shown that the perennial ice in the Arctic is thinning at a rate greater then current models predicted. Recent research suggests the thinning is beginning to have major regional and global consequences. The ARRV would provide a much needed, technologically advanced oceanographic platform to enable multidisciplinary teams to conduct field research at the ice edge and in seasonal ice (up to 2.5 feet thick) in order to address a variety of critical regional and global ecosystem issues, including climate change and ocean circulation.

Construction of the 236-foot vessel represents a major NSF contribution to the International Polar Year (IPY), a global research effort to better understand the polar regions and their climatic effect on the Earth. The plan is for the ARRV to replace the R/V Alpha Helix, the oldest and smallest federally-owned ocean-going vessel in the fleet, and which was decommissioned in 2007. ARRV would be able to accommodate some 500 researchers and students annually.

The anticipated operational lifetime of the ARRV is at least 30 years.

Status: The acquisition of the ARRV was approved by the NSB as a future MREFC project in August 2003. The design for the ARRV was completed in December 2004. In November 2006, two leading maritime international technology and business risk consultant companies provided NSF with independent design and cost analyses for the ARRV. This resulted in an updated cost estimate of $123 million. The ARRV design is now being updated to meet new regulatory requirements implemented since the completion of the December 2004 design. The independent cost estimates will also be refreshed to reflect the design update, and both activities will be completed in February 2008. The resulting manual of specifications and drawings will form the core document that will enable shipyards to develop construction bids.

In 2007, the University of Alaska, Fairbanks (UAF) was selected by NSF, following a competitive solicitation and external review, to manage the construction and carry out operation of the ARRV under a cooperative agreement. Also in 2007, an independent oversight committee was formed to provide advice and recommendations to NSF on the technical and scientific priorities for the vessel throughout planning and construction. It is anticipated that construction would commence early in FY 2009, assuming successful NSF review of the updated design package and UAF's solicitation of shipyard bids. Following a two-year construction period, an additional six-month period would be needed for delivery, sea trials, ice trials, shipboard scientific equipment testing, and any warranty adjustments, before scientific operations begin in 2012.

Partnerships: NSF expects to provide the funds for vessel construction. The operational funds will be provided in accordance with long standing Memoranda of Understanding (MOU) with NOAA and Navy.

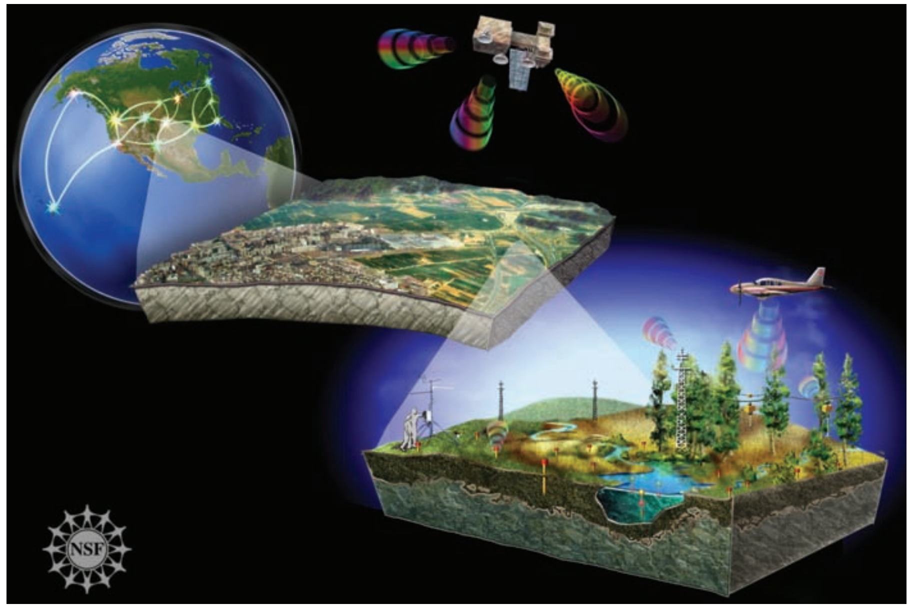
In accordance with these MOUs, the operational cost is prorated to each agency based on the number of days an agency or institution uses. Although NSF, Office of Naval Research (ONR) and NOAA are the major users of the Academic Fleet, other federal and state agencies are also expected to use the ship and would pay the same day rate.

NSF's Role: Programmatic oversight is the responsibility of the ARRV program director, located in GEO/OCE. NSF has organized ARRV construction activities into four distinct phases, with defined milestones and schedule requirements for each phase specified in the cooperative agreement. During the first quarter of 2008, NSF will conduct an external review of the phase one milestones, the updated technical design and management plan. During each of the following phases, an external review organized by NSF will assess milestone accomplishments before the subsequent phase is funded. The selection and issuance of phase one of the cooperative agreement was presented as an information item to the NSB in September 2007.

Annual support from all users for ship operation and maintenance is estimated at $9.5 million (in FY 2008 dollars). NSF support is provided through the GEO/OCE R&RA account.

Additional information on ARRV can be found at http://www.nsf.gov/pubs/2007/nsf07515/nsf 07515 .txt/.

NATIONAL ECOLOGICAL OBSERVATORY NETWORK (NEON)



The National Ecological Observatory Network is one of several NSF Earth-observing systems. This artist's conception depicts the distributed sensor networks and experiments, linked by advanced cyberinfrastructure to record and archive ecological data. Through aerial and satellite remote sensing, NEON will provide a "scalable" integrated research platform to conduct continental scale research.

Facility Objectives: The National Ecological Observatory Network (NEON), a regional-to-continental network of sensors and shared technology, is intended to provide the infrastructure needed to address the most complex environmental challenges facing the United States. Through remote sensing, *in situ* observation, experimentation, synthesis and modeling, NEON would provide multidisciplinary teams of researchers with the unique tools, technologies and data needed to advance our understanding of ecological theory and the interconnectedness of life. Investigators anticipate conducting real-time studies at unprecedented scales to address challenging research questions such as: How are ecosystems across the United States affected by changes in climate, land use, and invasive species over time? What is the pace and pattern of responses to those changes? How do biogeochemistry, biodiversity, hydro-ecology, and biotic structure and function interact with changes in climate, land use, and invasive species? How do these interactions vary with ecological context and scale? Research on these and related questions will lead to significant advances in our understanding of the consequences of the interplay among air, water, land and biota.

If constructed, NEON will be a "shared use" research platform of geographically distributed field and laboratory research infrastructure connected via cyberinfrastructure into an integrated research instrument. NEON infrastructure would include instrumented towers and sensor arrays, remote sensing capabilities, cutting-edge laboratory instrumentation, natural history archives, and facilities for data analysis, modeling, visualization, and forecasting—all networked onto a cyberinfrastructure backbone. Infrastructure would be deployed across the continental United States, Alaska, Hawaii and Puerto Rico using a statistically determined design.

NEON's support of educational activities would make it a national resource for ecological science education for K-12 teachers and students, higher education and the public.

The expected operational lifetime of NEON is 30 years if construction is approved and completed in FY 2016.

Status: NEON continues to develop its construction and operations plan. In 2007, NSF conducted a Preliminary Design Review (PDR) of NEON and the NSB approved an award to continue activities to bring NEON to a construction-ready stage. Enabling research and development (R&D) will be conducted to develop environmental sensors, promote network interoperability, and deliver tools for ecological modeling.

In FY 2008, NSF plans to conduct a further external review of NEON to evaluate issues identified during the PDR. NSF plans to conduct a Final Design Review (FDR) in Fall 2008 after NEON's Project Execution Plan and Environmental Assessments are finalized.

Partnerships: NSF funds the NEON, Inc. collaboration to undertake pre-construction planning of the NEON facility. An MOU between NSF and the USGS facilitates the sharing of remotely sensed satellite data, *in situ* verification, and archival storage by USGS of any NEON's remotely sensed aerial data. Since a number of the NEON infrastructure deployment sites could be located on U.S. Department of Agriculture (USDA) Forest Service lands, an MOU will allow NEON to partner with Forest Service research stations, enable data exchange, and facilitate permitting at a national level.

Once in operation, it is planned that NEON would be able to share data with the USGS Earth Resources Observations Systems Data Center and National Center for Atmospheric Research (NCAR). Data obtained from satellite remote sensing and NEON data would be combined to establish *in situ* verification of remote measurements. They will also assist with data archiving. It is expected that partnerships with the USDA's Agricultural Research Service and with the U.S. Forest Service would provide opportunities to link understanding of fundamental biological processes and production systems.

As envisioned, NEON would be a collaborative activity involving physical, computational, social, engineering and biological researchers. NEON is expected to provide significant research and technology development activities that can benefit interagency and international programs such as the U.S. Integrated Earth Observation System and the intergovernmental Group on Earth Observations, which is leading a worldwide effort to build a Global Earth Observation System of Systems (GEOSS).

NSF's Role: Programmatic oversight of NEON is the responsibility of the NEON program director located in the Division of Biological Infrastructure (DBI) within the Directorate for Biological Sciences (BIO).

In May 2007, NSF organized an external review of NEON. As a result of the recommendations stemming from this review, it is expected that the $100 million construction budget for NEON, shown in the table of MREFC account activity on page 6, will be revised as the project proceeds with the development of its Final Design. This budget was developed in 2002, following initial community workshops that broadly identified NEON's scientific scope, technical requirements, and potential management structure. Since then, adoption by NSF of rigorous pre-construction planning guidelines—and corresponding efforts by the ecological community to respond to these guidelines and to the recommendations from the May 2007 review—are resulting in improved definition of the project's intended scientific and technical scope, budget, and project implementation plans, including simultaneous deployment as one integrated national research platform, as recommended by the National Research Council (NRC) in 2004.

Prior to requesting NSB approval to obligate MREFC funds for construction, NSF will organize an external review of NEON's Final Design and proposal for construction, which will assess its scope, estimated project cost, risks, and schedule. A construction award is dependent on successful merit review of the proposed construction activities.

NSF intends to spend approximately $50 million from the R&RA account to support concept and development activities through FY 2008. It is planned that NEON's maintenance and operations would be funded through the BIO R&RA account at a level to be determined prior to the FDR in FY 2008. Additional information on NEON can be found at http://www.NEONinc.org and http://research.esd.ornl.gov/~hnw/neon/withindomainrep/.

OCEAN OBSERVATORIES INITIATIVE (OOI)

Facility Objectives: The Ocean Observatories Initiative (OOI) has the potential to revolutionize ocean science by providing the means to collect unique, sustained, time-series data sets that will enable researchers to study complex, interlinked physical, chemical, biological, and geological processes operating throughout the global ocean. The OOI would help researchers make significant progress in understanding such critical processes as climate variability, ocean food webs, coastal ocean dynamics and ecosystems, and global and plate-scale geodynamics. Scientific discoveries arising from the OOI would also provide exciting opportunities for ocean education and outreach through the capabilities for real-time data transmission and, particularly, real-time display of visual images from the seafloor.

If constructed the OOI would provide a globally distributed and integrated observatory network of platforms and sensors to obtain measurements within the ocean and below the seafloor, at temporal and spatial scales beyond the capability of tools and methods currently used to study ocean processes. As planned, the integrated observatory system would have three elements: a global component consisting of deep-sea buoys with capabilities appropriate to the experiments they will host, and with robust designs hardened to withstand harsh and remote environments, such as the Southern Ocean; a regional electro-optical cabled network consisting of interconnected sites on the seafloor spanning several geological and oceanographic features and processes; and new fixed and relocatable coastal observatories. OOI infrastructure would be deployed in the deep ocean at locations west of Canada and southern Chile, and south of Greenland, in the region of the Juan de Fuca plate in the Pacific Northwest and near the adjacent shore, and in the northeastern U.S. coastal region. Researchers would be able to access and control these marine assets in real or near-real-time through an interactive cyberinfrastructure.

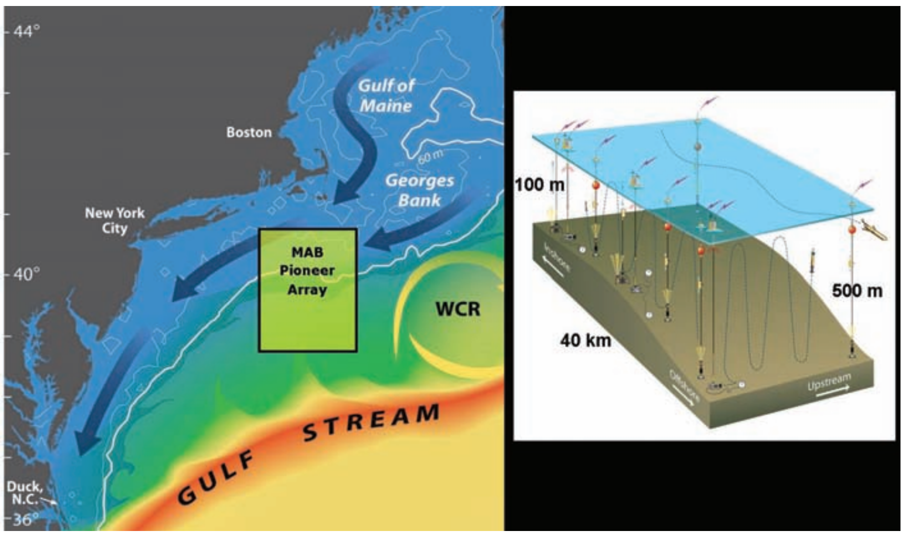


Figure depicts the initial location and configuration of the Pioneer Array, one of the coastal components of the Ocean Observatories Initiative. The Pioneer Array, initially located in the Middle Atlantic Bight, is a relocatable array consisting of a set of fixed moorings outfitted with a suite of multidisciplinary core sensors and complemented by a series of mobile assets including Autonomous Underwater Vehicles (AUVs) and gliders (gliders and glider paths not shown).

The expected operational lifetime of OOI, if constructed is 30 years.

Status: OOI is completing preconstruction planning activities. The OOI Project Team leading these activities consists of the OOI Project Office, based at the Consortium for Ocean Leadership (Ocean Leadership), and three subawardees to Ocean Leadership: the University of Washington; Woods Hole Oceanographic Institution; and the University of California, San Diego/Scripps Institution of Oceanography. These institutions and their partners will be responsible for the anticipated design and construction of the regional scale nodes, coastal/global scale nodes, and cyberinfrastructure, respectively. All three subawardees began design work in 2007. Building upon significant community planning efforts and NSF input, the OOI Project Team produced the Preliminary Network Design and the OOI Project Execution Plan.

NSF conducted an external review of these materials in December 2007 to insure that they satisfied NSF's PDR and FDR criteria. The OOI Project Team and its subawardees will continue to refine design and planning efforts, addressing the recommendations resulting from a Blue Ribbon Panel science review, the PDR/FDR external review panel, and guidance from NSF. Results of the science review and the PDR/FDR, if successful will be submitted to the NSB as part of the process to request approval to commence construction.

If approved OOI construction is expected to require about five years.

Partnerships: OOI is closely coordinating the design of its NSF-funded regional scale nodes with a similar effort underway by the Canadian NEPTUNE Project (now in its implementation phase) to establish a complementary observatory network in the eastern Pacific in the area of the Juan de Fuca Plate. The selection of sites for the OOI global buoys has been coordinated with input from NOAA's Global Climate Buoy Program and the international OceanSITES Program.

Construction and operation of OOI are expected to provide significant R&D experiences that will benefit interagency and international programs or activities such as the U.S. Integrated Ocean Observing System, the U.S. Integrated Earth Observation System and the intergovernmental Group on Earth Observations, which is leading a worldwide effort to build a Global Earth Observation System of Systems (GEOSS).

NSF's Role: Programmatic oversight of OOI is the responsibility of the OOI Program Director located in GEO/OCE. NSF conducted a series of external reviews of OOI in 2006 and 2007 to assess the OOI design and whether it provides the infrastructure needed to address key science drivers, as well as to assess the management, scope, and budget of the OOI project and its execution.

Following NSB approval to obligate construction funds, a cooperative agreement would be implemented to award MREFC funds to begin the 5-year construction effort. Operation and maintenance funding would be phased in as components of OOI come on-line. Comprehensive annual external reviews of progress would be held throughout the construction period; these reviews would also assess operational activities once those efforts become significant. Reviews would be interspersed with monthly and quarterly progress reports, site visits, weekly teleconferences and frequent internal NSF project oversight and management meetings.

NSF support for annual operations and maintenance via the GEO/OCE R&RA account is estimated to ramp up to $50 million in FY 2013.

Additional information on OOI can be found at http://www.oceanleadership.org/ocean_observing.

NEW STARTS IN FY 2008

ADVANCED LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY (AdvLIGO)

Facility Objectives: The Advanced Laser Interferometer Gravitational Wave Observatory (AdvLIGO) is a planned upgrade that will improve by a factor of 10 the sensitivity of the Laser Interferometer Gravitational-wave Observatory (LIGO), the current Earth-based facility now used by researchers to detect elusive gravitational waves. Already one of the most advanced scientific instruments ever built, LIGO is at the forefront of a world-wide effort to directly detect gravitational waves. However, although Albert Einstein predicted their existence in his 1918 general theory of relativity, gravitational waves—ripples in the fabric of space-time produced by rare cataclysmic events throughout the universe—have never been directly observed. Since the volume of space that the instrument can

Engineer Stephany Foley of MIT LIGO is aligning the elements of a prototype test mass suspension for the planned Advanced LIGO Gravitational Wave detector. In this prototype, the cylindrical mirrors are replaced with metal pieces to allow testing on a less fragile system. It is suspended from an optics table on an Advanced LIGO seismic isolation system.

examine varies as the cube of the sensitivity, AdvLIGO would look at a volume of space 1,000 times larger. This makes just a few hours of AdvLIGO observation time the equivalent of one year of LIGO observations—greatly enhancing the chances of directly observing gravitational waves.

LIGO consists of three Michelson interferometers situated at Hanford, Wash., and Livingston, La.—locations approximately 3,000 km apart. Each interferometer is able to measure extraordinarily small relative changes in the optical path lengths of two orthogonally oriented, kilometer-scale arms. The changes are expected to result from tiny distortions of space-time caused by the passage of gravitational waves. The 3,000-km separation between the two sites ensures that the very small signals induced by gravitational waves can be distinguished from local sources of random noise that may affect one site, but not both sites simultaneously.

Data collection at LIGO began in 2002. The three initial interferometers have now surpassed their design sensitivity and have just completed their mission-defining search for gravitational waves. (For more about LIGO, see the description on page 32.) The upgrade to AdvLIGO, vastly increasing its sensitivity, also comes with a change in the bandwidth of high sensitivity and the ability to tune the instrument for specific astrophysical sources. This upgrade is necessary to maintain U.S. leadership in this area of fundamental physics and keep pace with competing instruments abroad, which are also receiving upgrades.

If constructed, the expected operational lifetime of AdvLIGO is 20 years.

Status: AdvLIGO is completing its pre-construction planning activities. The LIGO Laboratory submitted a proposal for AdvLIGO in early 2003; a subsequent review judged the project to be scientifically sound and ready for construction. Since then, a continuing R&D program has enhanced readiness, solidified costs and schedule estimates, and reduced risk. A 2006 baseline review panel concluded that AdvLIGO could be built to the project's submitted cost, schedule and execution plan. A 2007 baseline update review panel endorsed the continued validity of the project's plans and cost estimate. In November 2007, NSF conducted an FDR that determined the estimated project cost continued to be as previously estimated and that the project was ready for an immediate start.

AdvLIGO funding in FY 2008 would allow the purchase and assembly of upgraded components for the upgraded interferometers. Continued operation during this initial period would allow tests of AdvLIGO components and would allow an extended science run at enhanced sensitivity. LIGO would be decommissioned in 2011, when the replacement of its core components would begin, although some operations would continue.

AdvLIGO could be expected to begin full operation in 2015.

Partnerships: If the start of construction is approved, NSF will fund the California Institute of Technology (Caltech), in partnership with Massachusetts Institute of Technology (MIT), to lead the efforts to build and commission AdvLIGO. Essential contributions will come from Britain and Germany. The University of Glasgow will develop AdvLIGO's mirror suspension system, while Laser Zentrum Hannover is already providing new higher power laser systems. The LIGO program has strongly stimulated gravitational-wave research around the world, producing vigorous competing programs in other countries that also collaborate with LIGO to provide it with many necessary scientific advances. The LIGO Scientific Collaboration (LSC), which carries out LIGO's research program, consists of approximately 580 scientists from more than 48 institutions in 11 countries.

NSF's Role: Programmatic oversight of the AdvLIGO project is the responsibility of a program director in MPS/PHY. NSF conducts annual scientific and technical reviews, participates in LSC meetings, and makes site visits. During AdvLIGO's construction phase, NSF would exercise more intensive oversight through more frequent reporting requirements, stepped-up interaction with project personnel, annual external reviews of construction progress, and site visits.

NSF support for annual operations via the MPS/PHY R&RA account is estimated to rise to $39 million by the time construction is expected to be completed in FY 2015.

Additional information on LIGO and AdvLIGO can be found at http://www.ligo.caltech.edu/.

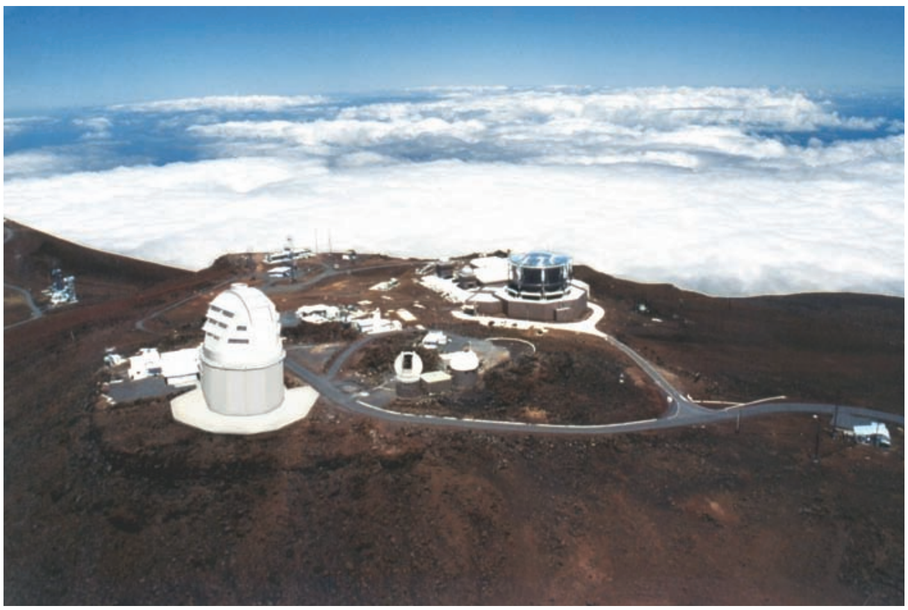
INITIAL FUNDING IN MREFC FY 2009

ADVANCED TECHNOLOGY SOLAR TELESCOPE (ATST)

Facility Objectives: The Advanced Technology Solar Telescope (ATST), proposed to be the first large U.S. solar telescope to be constructed in 30 years, would provide unprecedented observations of solar plasma processes and magnetic fields, and enable a deepening of our understanding of our nearest star, the Sun. ATST would reveal critical information needed to explore crucial mysteries such as: What are the mechanisms responsible for solar flares, coronal mass ejections and space weather, with their associated impact on satellites, communications networks, and power grids? What are the processes that cause solar variability and its impact on the Earth's climate and evolution? How does the solar dynamo work to generate the star's titanic magnetic field? What causes the heating of the chromosphere and the corona, which is hundreds of times hotter than the surface of the Sun? What can the Sun teach us about other solar-type stars, cosmic magnetic fields and other plasma structures in the universe?

in existence, and adaptive correction would yield an increase in angular resolution of a factor of three to seven over the best adaptively corrected systems currently available. The ATST would allow researchers to resolve features of about 30 km in size on the Sun to observe at the fundamental length scales needed to test current theories of solar magnetism and activity.

ATST would be profoundly important—not only to solar scientists, but to a diverse



A rendering of the proposed Advanced Technology Solar Telescope (ATST) as it would appear with the existing facilities of Haleakala High Altitude Observatories, from the southwest above the 10,000 foot summit of Haleakala on Maui, Hawaii.

ATST has the potential to become the world's flagship facility for ground-based solar physics observation. The 4-meter, off-axis Gregorian (all reflective) telescope with integrated adaptive optics would have a field of view of 3 arc minutes, an angular resolution of < 0.03 arc seconds, and wavelength sensitivity that spans the entire visible and near-infrared regions of the electromagnetic spectrum. Its light grasp would be a factor of ten greater than the largest solar telescope

group of scientists that includes astrophysicists and plasma physicists. As a national facility, ATST would enable training of the next generation of solar physicists and instrument builders at the graduate and undergraduate levels. ATST could contribute to curriculum development and teacher training through ongoing NSO programs and to public outreach through the NSO Visitor Center and other programs.

If constructed, the expected operational lifetime of ATST is 50 years.

Status: The ATST project conducted an extensive and successful Conceptual Design Review (CDR) in August 2003. A detailed cost review was held in March 2005 and a set of systems design reviews was conducted during 2005 and 2006. The ATST project is currently engaged in advanced pre-construction planning activities following a successful PDR, conducted by NSF in October 2006. The project has selected Haleakala Peak on the island of Maui in Hawaii as its site. The environmental and cultural assessment processes for this site are well advanced.

Because it would be the first new large solar telescope constructed in nearly 30 years, and because of the new range of scientifically compelling questions that ATST can address, the construction could be expected to rejuvenate the solar research community in U.S. universities. There are approximately 500 potential users in the United States. Additionally, as the preeminent facility for detailed ground-based studies of the Sun, ATST would draw from the world's entire community of solar physicists and astronomers.

The construction duration is not yet known. It will be determined as part of the development of the project baseline, taking into account those activities needed to satisfy environmental and cultural regulatory requirements.

Partnerships: The ATST is a collaboration of 22 institutions from the U.S. and eight other countries. The project is managed by NSO. NSO provides the world's forefront collection of solar telescopes for investigators supported by MPS/AST and GEO's Atmospheric Sciences Division (ATM) to study space weather and atmospheric implications of solar activity.

Strong linkages have been established among a diverse set of collaborating institutions, including universities, industrial partners, NASA centers, and other Federally Funded Research and Development Centers, as well as the world-wide community of solar physicists and astronomers. Interagency partners include: the Air Force Office of Scientific Research, a long-standing partner in NSO; NASA Goddard Space Flight Center, which plans to provide a 12-micron Stokes polarimeter as a dedicated instrument for the ATST; and NASA Marshall Space Flight Center, which is contributing to the definition and design of the ATST imaging vector magnetograph. The European solar physics community is actively trying to raise funds to support the construction.

NSF's Role: Programmatic oversight is the responsibility of a Program Director in MPS/AST, who works directly with the ATST Project Manager and Project Director, both at NSO. NSF currently provides approximately $3 million annually from the MPS/AST R&RA account to support continued design and development of the ATST project.

NSF organized a PDR in October 2006, utilizing an external panel of scientific, technical, and managerial experts, to evaluate the robustness of the telescope and the facility's technical design, and the proposed budget, schedule, project execution plan, and risk management plan. The review determined that the design, budget and plans provide a firm basis for requesting future construction funding. At their August 2007 meeting, the NSB approved the inclusion of the ATST in a future budget at the Director's discretion. Were construction to begin in FY 2009, full science operation could begin in 2015.

NSF support for annual operations and maintenance via the MPS/AST R&RA account, is estimated at $13 million.

Additional information on the ATST can be found at http://atst.nso.edu.

READINESS STAGE PROJECTS

The MREFC panel annually evaluates projects for admission to this category. Characteristics of facilities in this category, and their objectives for further development, are described in NSF's Large Facilities Manual[4]. The sponsoring Directorates and Offices bring candidates forward when those organizations consider the projects ready for MREFC funding consideration. At the time of preparation of the 2008 Facility Plan, there were no projects in this category.

4 NSF 07-38, available on-line at: http://www.nsf.gov/pubs/2007/nsf0738/nsf0738.pdf.

CHAPTER TWO

STATUS REPORTS OF EXISTING FACILITIES AND NON-MREFC INFRASTRUCTURE

The panorama of Kitt Peak, stretching from the WIYN 3.5-meter telescope on the far left to the Mayall 4-meter telescope on the far right, with the Synoptic Optical Long-term Investigations of the Sun (SOLIS) tower and the triangular McMath-Pierce solar facility in the foreground.

EXISTING FACILITIES AND NON-MREFC INFRASTRUCTURE

As outlined in the Introduction, this section provides brief descriptions of NSF's major facilities and research infrastructure that were given new or renewal awards through the Research and Related Activities (R&RA) account within the last two years.

NATIONAL OPTICAL ASTRONOMY OBSERVATORY AND NATIONAL SOLAR OBSERVATORY (NOAO AND NSO)

Facility Objectives: The National Optical Astronomy Observatory (NOAO) and National Solar Observatory (NSO) operate telescopes and supporting instrumentation that enable research on some of the most compelling science questions of the new millennium in astronomy and solar physics. The facilities provide researchers with powerful and sophisticated tools to peer deep into space and back in time to investigate age-old questions and unexplained phenomena including the expansion of the Universe, the formation and evolution of galaxies and individual stars, the evolution of planetary systems, and the generation, structure and dynamics of the solar surface magnetic fields. The telescopes have been used in work leading to some of the most profound breakthroughs in astronomy and cosmology in recent years. For example, the NOAO 4-meter telescope in Chile enabled the remarkable 1998 discovery of the accelerating rate of the expansion of the Universe, which led to the realization that the Universe is permeated with a mysterious "dark energy." Understanding the nature of dark energy is one of the most sought-after prizes in contemporary physics.

NOAO operates Kitt Peak National Observatory (KPNO) near Tucson, Ariz., and Cerro Tololo Interamerican Observatory (CTIO) near La Serena, Chile. NOAO's Gemini Science Center in Tucson also coordinates access for U.S. astronomers to the twin Gemini 8-meter telescopes in Hawaii and Chile. The NSO operates facilities in Sunspot, N.Mex., and at KPNO. These facilities offer the world's largest collection of optical and infrared solar telescopes and auxiliary instrumentation for observation of the solar photosphere, chromosphere, and corona, as

An image of the galaxy NGC1365 in the constellation of Fornax as seen through the Blanco 4-meter telescope of the National Optical Astronomy Observatory.

well as a coordinated worldwide network of six telescopes specifically designed to study solar oscillations.

NOAO and NSO are deeply involved in the education and training of the next generation of astronomers and solar physicists. The observatories provide research and training opportunities through Research Experiences for Undergraduates (REU) programs and graduate student use of the facilities to conduct research for their advanced degrees. Modern visitors' centers at each site promote public understanding of and interest in astronomy and science. The observatories also maintain Web sites for on-line access to image galleries and other outreach content, and they have K-12 programs serving the local communities. NOAO also has an ongoing outreach program to the Tohono O'Odham Nation, on whose land KPNO sits.

KPNO began operation in 1958, CTIO was founded in 1963, and NSO was transferred to NSF support from the USAF in 1976.

Status: NOAO has begun a multi-year effort to introduce new capabilities to the U.S. community through new investment at KPNO and CTIO and through additional access to non-federal observatories. NOAO is managing 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 is also administering the Telescope System Instrumentation Program that supports the development and fabrication of instrumentation at non-federal observatories in return for competitively reviewed observing time for the general U.S. community. 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 users annually. NSO is leading the community in the design and development of the ATST,[5] another high priority in the Decadal Survey for astronomy.

NOAO and NSO are managed and operated by the Association of Universities for Research in Astronomy, Inc., (AURA) under a five-year Cooperative agreement that was competed and awarded in October 2002. A management review was conducted in August 2006. On the basis of that review, the National Science Board (NSB) authorized extension of the current Cooperative Agreement through March 2009, and NSF requested a proposal from AURA for a Cooperative Agreement to run from April 2009 through March 2014.

Partnerships: Thirty-three U.S. member institutions and seven international affiliate members comprise the Member Institutions of AURA. Other partners with NOAO and NSO include the USAF Office of Scientific Research, NASA, the DOE, and industrial vendors. Development of new telescopes, instrumentation, and sensor techniques is done in partnership with relevant industry participants, through sub-awards to large and small aerospace firms, optical fabrication firms and IT companies.

NSF's Role: Programmatic oversight of NOAO and NSO is the responsibility of the NSF Program Director in MPS/AST, in consultation with community representatives. The program director makes use of detailed annual program plans, long range plans, and quarterly and annual reports that are submitted to NSF by the facilities. The Program Director also attends AURA governance committees. AURA manages the observatories through community-based Observatory Councils and Users' Committees. Separate directors for NOAO and NSO report to the president of AURA.

NSF's combined annual support for NOAO and NSO operations and maintenance is currently approximately $38 million.

Additional information on the ATST can be found at http://www.noao.edu and http://www.nso.edu.

NATIONAL ASTRONOMY AND IONOSPHERE CENTER (NAIC)

Facility Objectives: The National Astronomy and Ionosphere Center (NAIC), the world's largest single-dish radio telescope, is used in radio astronomy, solar system radar astronomy and ionospheric physics. Radio astronomers and planetary scientists use the NAIC facility to study such diverse areas as interstellar gas, galactic structure formation and evolution, pulsars, the complex interactions between the Earth's magnetosphere and the solar wind, and topics in solar system astronomy, such as the physical properties of asteroids, planetary surfaces and moons. The facility has been used for ground-breaking research by many prominent scientists over the decades, including at least two Nobel laureates: Russell Hulse and Joseph Taylor. They used the facility to study the evolution of the orbits of binary neutron star systems, where one of the orbiting starts is a pulsar,

5 For more information, see the ATST Project description on page 22.

The NAIC facility's 305-meter-diameter reflector is the world's largest single-dish radio telescope. It is used to conduct research in radio astronomy, planetary radar and terrestrial aeronomy.

to confirm the formulation of gravitational radiation contained in Einstein's General Theory of Relativity.

The NAIC facility, located in western Puerto Rico near the town of Arecibo, has a 305m-diameter primary reflector. The facility provides telescope users with a wide range of research instrumentation, including an L-Band Feed Array, essentially a seven-pixel camera that allows astronomers to collect data about seven times faster than before.

In addition to enabling frontier research, NAIC has a primary education goal to provide research and training opportunities for undergraduate and graduate students. The facility was one of NSF's first sites for the REU program, and graduate students use the telescope to conduct Ph.D. research. NAIC 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. The facility attracts roughly 120,000 visitors per year, including many K-12 school groups from across Puerto Rico.

The operational life and future use of NAIC are under review by NSF, in partnership with the scientific communities it serves. NAIC has been operating since 1962.

Status: NAIC is operated by Cornell University for NSF under a cooperative agreement. Funding for management, operations and maintenance primarily maintains and utilizes existing facilities and develops new instrumentation in support of research by the national astronomical community. It serves over 250 users annually.

On October 1, 2005, a new 54-month cooperative agreement, with Cornell University as facility manager, went into effect with funding authorization provided by the NSB for only the first 12 months. In March 2007 the Board authorized funding for the remainder of the cooperative agreement (through March 31, 2010). Reductions to NAIC funding were recommended by the AST Senior Review to enable redirection of NSF investments towards more advanced astronomical infrastructure. This has resulted in reductions in staff and limited operating modes while NAIC explores avenues for obtaining additional funding.

Partnerships: NAIC currently has external partnerships with Haystack Observatory, NRAO,

Suspended platform structure of the telescope, with the dome that houses the Gregorian optics. Radio waves reflected first from the spherically shaped 305-meter-diameter main dish are then focused by secondary and tertiary reflectors within the dome to form a point-like radio image. The platform is suspended in free space by three sets of cables 450 feet above the dish surface, and weighs 900 tons.

UC-Berkeley, and Columbia University to develop next generation instrumentation and data analysis techniques, with the University of Puerto Rico-Humacao to jointly construct an 18 meter, ancillary telescope to be used with the 305-meter Arecibo telescope in international very long baseline interferometry (VLBI) programs and as a stand alone instrument for educational purposes; and with the University of Texas, Brownsville to investigate enhanced gravitational wave searches by using pulsar timing. European Union Framework 6 funds NAIC's participation in the European EXPReS project to develop the technique of real-time VLBI over the internet. NASA, a historical partner for planetary radar, terminated funding in 2005.

In collaboration with NRAO, NAIC holds a summer school on single-dish radio astronomy techniques. NAIC also has a long-term association with the Angel Ramos Foundation of Puerto Rico. NAIC has submitted and been granted a continuing series of proposals for new displays in the Visitor Center, and most recently for a refurbishing of many of the existing Visitor Center displays.

NSF's Role: Programmatic oversight is the joint responsibility of the NSF program managers located in MPS/AST and GEO/ATM. Within NSF, NAIC is co-funded by AST and ATM. NSF's cooperative agreement with Cornell University requires that an annual progress report and program plan be submitted to and approved by NSF. Bi-weekly teleconferences are maintained between NSF and the NAIC Director. The NSF program managers visit the observatory several times a year. Arecibo Visiting Committee meetings (commissioned by Cornell) are attended by the NSF program managers, and committee reports are made available to NSF. Yearly status reports and long-range plans are presented by NAIC/Cornell representatives in visits to NSF. NSF conducts an external management review typically during the third year of each 5-year cooperative agreement.

Annual support for NAIC operation and maintenance is currently approximately $12 million and is provided from the MPS/AST and GEO/ATM R&RA accounts.

More information about NAIC can be found at http://www.naic.edu/.

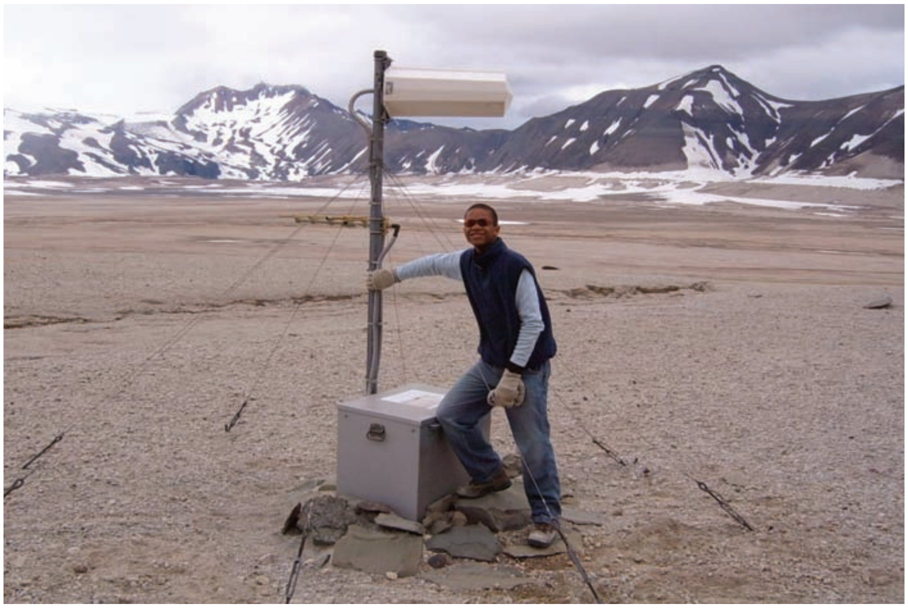
INCORPORATED RESEARCH INSTITUTIONS FOR SEISMOLOGY (IRIS)

Facility Objectives: The Incorporated Research Institutions for Seismology program (IRIS) enables the rapid collection and distribution of seismological data for studies of earthquakes and Earth structure. The distributed national facility provides for the development, deployment, and operational support of modern digital seismic instrumentation for earthquake and other Earth sciences research and for nuclear test ban monitoring. The Earth's interior is a major scientific frontier, and IRIS data have played a vital role in scientists' work to develop a better understanding of the physical processes underlying our restless planet. For example, researchers mining the data archive from IRIS' Global Seismographic Network (GSN)—a network of 138 permanent seismic stations around the world, most providing real-time access to data—discovered glacial earthquakes, a previously unknown class of low frequency "earthquakes" produced by sudden glacial sliding. Further research could determine if the strong seasonality and increasing frequency of these glacial earthquakes are indicative of a glacial response to climate change.

In addition to the GSN, IRIS has three other major elements: the Program for the 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; the IRIS Data Management System (DMS), which provides the national and international seismic research community with timely access to some 70 terabytes of data from the GSN and PASSCAL as well as data contributed by U.S. and international sources; and an education and outreach 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.

IRIS began operation in 1984.

Status: The IRIS consortium was founded by 26 universities in response to recommendations in a report issued in 1983 by the Committee on Science, Engineering, and Public Policy (COSEPUP) of the National Academies. This report urged that "NSF act as overall coordinator and lead agency for funding a global digital seismic array and that the operation be planned and overseen by a university consortium."



Summer intern assisting with IRIS field work in Katmai National Park, Alaska.

During the last twenty-three years, with support from NSF and federal partners, the IRIS consortium has grown to 110 full-member (voting) U.S. universities that manage and operate the core research facilities. 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.

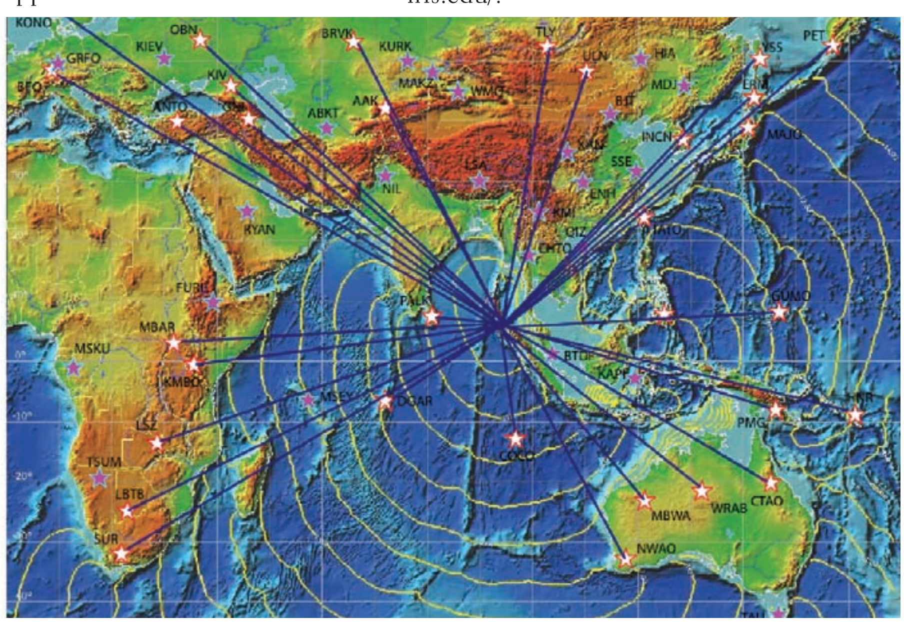
Partnerships: IRIS is heavily involved in many international and domestic partnership activities. Installation and operation of the GSN has put IRIS in contact with scientists as well as government and non-government organizations from around the world. Many international IRIS GSN stations are designated as the official stations for nuclear test ban monitoring in their host countries. International teams of scientists organize most PASSCAL projects overseas. 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 (USGS), and accelerated development of the PASSCAL instrument pool (DOE).

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 the commercial sector in development of seismic instrumentation and software.

NSF's Role: EAR/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. An interim management review will be conducted by NSF during the new award period.

Annual support for IRIS operation and maintenance is approximately $12 million and is provided through the GEO/EAR R&RA account.

Additional information on IRIS can be found at: http://www.iris.edu/.



Map of IRIS Global Seismographic Network (GSN) stations used by the Pacific Tsunami Warning Center (PTWC) during the 2004 Indian Ocean tsunami.

NATIONAL HIGH MAGNETIC FIELD LABORATORY (NHMFL)

Facility Objectives: The National High Magnetic Field Laboratory (NHMFL) develops and operates state-of-the-art, high-magnetic-field facilities and is among the preeminent facilities in the world for researchers and engineers studying superconductivity and other materials research. The facility seeks to provide the highest magnetic fields for scientific research. It holds numerous records—including the current Guinness World Record for highest magnetic field for a continuous field magnet of 45 Tesla—which is about one million times the Earth's magnetic field. The record-setting measure provides researchers with a unique scale of magnetic energy to create novel states of matter and probe deeper into electronic and magnetic materials. High magnetic fields are crucial to fundamental research advances in a broad range of disciplines including biology, biochemistry, bioengineering, chemistry, engineering, geochemistry, materials science, medicine and physics. For example, an international team of scientists working with the highest magnetic fields at the NHMFL and in the Netherlands recently observed the quantum Hall effect—a much studied phenomenon of the quantum world—at room temperature. Before the surprising discovery, it was believed to be observable only at temperatures close to absolute zero (equal to minus 459 degrees Fahrenheit or minus 273 degrees Celsius). In cooperation with industry, NHMFL also advances magnet and magnet materials technology.

NHMFL's educational efforts seek to provide research and training opportunities to undergraduate and graduate students, contributing to the development of the next generation of scientists, engineers, and science education leaders. Capitalizing on the unique resources available within the laboratory, NHMFL also provides a variety of programs, opportunities, and mentorship experiences for teachers and students at all academic levels. Annual regional K-12 outreach efforts engage over 7,000 students from Florida and neighboring Georgia in hands-on science activities and tours of the laboratory. NHMFL seeks to become a nationally recognized leader in the diversity of its scientific, technical and engineering staff by actively working with and recruiting students from underrepresented groups—from grade school to graduate school—to encourage women and minorities to pursue careers in scientific research.

NHMFL has been in operation since 1994.

Status: NHMFL is operated for NSF by a consortium of three institutions: Florida State University (FSU), the University of Florida, and the Los Alamos National Laboratory (LANL). It is the world's largest and highest field strength magnet laboratory, outfitted with a comprehensive assortment of high-performing magnet systems. Every year, more than 900 visiting scientists and engineers from across the world conduct experiments using NHMFL's state-of-the-art equipment.

The most recent cooperative agreement for the support of NHMFL operations expired at the end of 2007. During FY 2007, NSF conducted an external review of the consortium's proposal to renew the cooperative agreement for management and operation.

NHMFL technicians replace a coil for the Magnet Lab's world-record 35 Tesla all-resistive magnet.

In August 2007, the NSB authorized NSF to renew the award for the five-year period extending until the end of 2013.

Partnerships: The NHMFL is principally supported by the Division of Materials Research (DMR), with additional support provided by the Chemistry Division in MPS. The State of Florida is the primary partner, providing substantial support both in direct cost-sharing and cost contribution. The DOE, through LANL, supports research and instrument development at the pulsed field laboratory at LANL. The National Institute of Health (NIH) supports instrumentation and research using the magnetic resonance facility at NHMFL.

The laboratory engages in numerous consortia. NHMFL scientists work with academic and non-academic private partners in diverse areas of magnet technology. The laboratory collaborates with more than sixty private sector companies including American Magnetics, Exxon Mobil Corporation, and Oxford Instruments; as well as with other national facilities such as the Spallation Neutron Source and the Advanced Photon Source. International partners include the Hahn-Meitner Institute and the Korea Basic Science Institute. In addition, the NHMFL has established numerous partnerships and programs to enhance science education and public awareness.

NSF Role: Programmatic oversight of the NHMFL lies with the National Facilities Program in DMR, with guidance from an *ad hoc* working group with representatives from the Division of Chemistry (MPS), the Directorate for Engineering, and the BIO Directorate. Site visit reviews are conducted annually. Representatives from DOE and NIH participate as observers at the site visits. The reviews assess the user programs (access and service), the in-house research programs, the facility operations and development, including magnets, and instrumentation, the education training and outreach, the long-term plans of the NHMFL to contribute significant research developments both nationally and internationally, the efficiency of operations and management of the facility, and the plan for diversity.

Annual support for NHMFL operations and maintenance is currently approximately $26.5 million.

Additional information about NHMFL can be found at http://www.magnet.fsu.edu/.

LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY (LIGO)

Facility Objectives: The Laser Interferometer Gravitational Wave Observatory (LIGO) is now at the forefront of the relatively new field of gravitational-wave astronomy. LIGO is capable of detecting gravitational waves, or ripples in the fabric of space-time, produced by rare cataclysmic events emanating from supernovae, pulsars, and neutron star collisions occurring as far away as 50 million light years, and black hole mergers occurring at still greater ranges throughout the universe. Though Albert Einstein predicted their existence in his 1918 general theory of relativity, gravitational waves have never been directly observed. LIGO was constructed to detect and measure these faintest of signals reaching Earth from space and, at the same time, test fundamental predictions of physics. Its instruments were designed to be sensitive enough to measure displacements as small as one-thousandth of the diameter of a proton. Since data collection began in 2002, LIGO has been contributing to the 21st century quest to reconcile Einstein's General Theory and Quantum Mechanics, the two preeminent and, so far, incompatible frameworks describing the Universe.

LIGO consists of three Michelson interferometers situated at Hanford, Wash., and Livingston, La.—locations approximately 3,000 km apart. The 3,000-km separation between the two locations insures that the very small signals induced by gravitational waves in the LIGO apparatus can be distinguished from local sources of random noise that may affect one, but not both, sites simultaneously. (A major upgrade to greatly increase the facility's sensitivity has been announced; see the AdvLIGO description on page 21 for information about planned improvements as well as the facility's current capabilities.) LIGO provides research and training opportunities for undergraduate and graduate students through a vigorous REU program and graduate student use of the facility to conduct Ph.D. research. The LIGO Livingston Observatory is home to a recently constructed

Aerial view showing the twin 4-km long arms of the interferometer at the Hanford, Washington, LIGO site.

Aerial view of the LIGO site at Livingston, Louisiana, looking south along one of its two interferometer arms.

Science Education Center. In collaboration with Southern University, it provides regional pre-service and in-service training on LIGO-related science to K-12 school teachers. Thousands of students and members of the public tour the Hanford and Livingston sites each year.

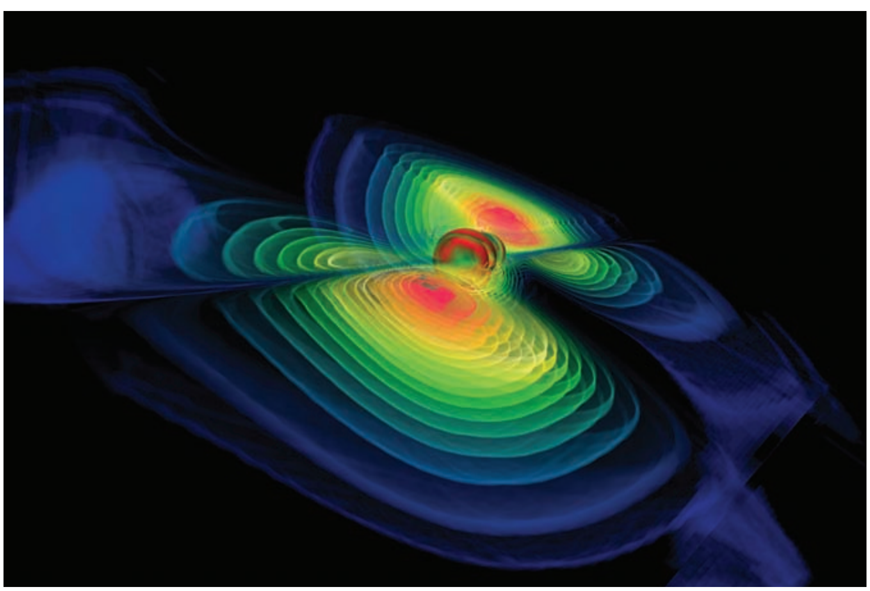
LIGO began initial operation in 2001. The anticipated operational lifetime of LIGO following the major upgrade about to start is 20 years.

Status: At the end of FY 2007, LIGO completed a year-long science run, collecting one cumulative year of data while simultaneously operating all three interferometers at levels of sensitivity that met or exceeded initial design goals. In FY 2008, LIGO will begin preparations for the AdvLIGO upgrade, including preparations for an extended observational run scheduled to begin in FY 2009. The major purpose of this run will be to test components of AdvLIGO. A sensitivity increase of a factor of two over that of initial LIGO is expected, and significant scientific findings are expected. LIGO is planned to be decommissioned in 2011, when the replacement of its central components will begin. Many operations, including data analysis and AdvLIGO R&D, will continue, however. The upgrade will be completed in 2015, when LIGO will resume full operation. The LSC, which carries out LIGO's research program, consists of approximately 580 scientists from more than 48 institutions in 11 countries.

LIGO is operated for NSF through a cooperative agreement with Caltech, with MIT as a major partner. The cooperative agreement expires at the end of FY 2008. Caltech has submitted a new proposal for LIGO operations for FY 2009 – FY 2013 that is coordinated with the MREFC-funded major upgrade. The proposal for continued operations was reviewed by an NSF panel in November 2007.

Partnerships: The LIGO program has strongly stimulated gravitational-wave research around the world, producing vigorous competing programs in other countries that also collaborate with LIGO to provide it with many necessary scientific advances. LIGO has entered into a close data-sharing agreement with Virgo, a French–Italian gravitational-wave observatory. GEO600, the German-British Gravitational Wave Detector, is a member of the LSC, which carries out LIGO's research program. The LSC consists of approximately 580 scientists from more than 48 institutions in 11 countries.

NSF's Role: NSF oversight is coordinated internally by a program director in MPS/PHY. NSF conducts annual



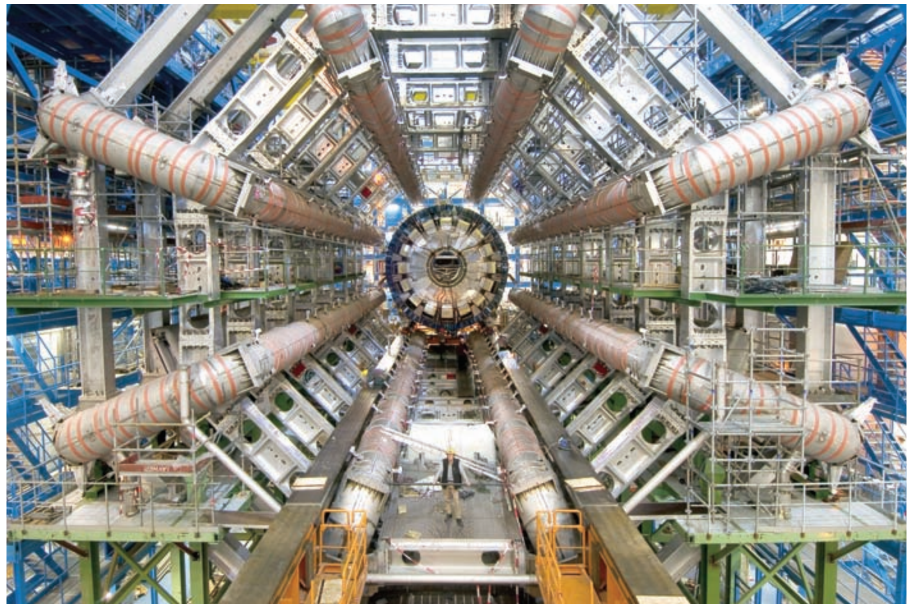
The image shows a model of a collision between two black holes, which is one of the violent phenomena that new LIGO equipment might be able to detect.

scientific and technical reviews, participates in LSC meetings, and makes site visits. NSF oversight will increase during the AdvLIGO construction period.

NSF support for annual operations and maintenance of approximately $29.5 million is provided via the MPS/PHY R&RA account. This support is planned to increase to approximately $39 million in FY 2015 at the conclusion of the AdvLIGO upgrade.

Additional information on LIGO and AdvLIGO can be found at http://www.ligo.caltech.edu/.

LARGE HADRON COLLIDER (LHC) DETECTOR OPERATION



The ATLAS experiment at the European Organization for Nuclear Research (CERN).The largest-volume detector ever constructed, ATLAS is 148 feet long, 82 feet wide and 82 feet high, and weighs about 7,700 tons.

Facility Objectives: The Large Hadron Collider Detector Operation (LHC), under construction at the European Organization for Nuclear Research (CERN) Laboratory in Geneva, Switzerland, will be the world's premier facility for research in elementary particle physics. The high-energy accelerator will smash protons into protons, creating brief showers of very exotic material that physicists will examine as they seek out new types of matter. 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 facility will also enable a search for particles predicted by a powerful theoretical framework known as supersymmetry, which could provide clues to how the four known forces evolved from different aspects of the same unified force in the early universe. A further objective for LHC physicists is the investigation of the possible existence of extra dimensions in the structure of the universe, as posited in string theory.

NSF's contribution to the LHC international project includes support for the construction, maintenance and operation of two detectors, A Toroidal LHC Apparatus (ATLAS) and the Compact Muon Solenoid (CMS). These detectors were built to characterize the different reaction products produced in the very high-energy proton-proton collisions that will occur in interaction regions where the two counter-circulating beams collide.

The facility's education goals include providing undergraduate and graduate students with research opportunities and training, and informing the public, students, and teachers about the particle physics to be done with the LHC detectors. In addition to REU and formal graduate student research programs, the facility will provide scientists involved in the detectors with information and educational materials to assist outreach efforts to the public, officials, news media, students and teachers.

The LHC is slated to begin operation in 2008. The associated particle detectors supported by NSF are planned to have operational lives of 10 years, with a possible extension of 10 years if a projected upgrade of the LHC is approved.

Status: The U.S. LHC Collaboration is in the midst of completing the installation of detector components in the experimental areas. Experimenters are also busy integrating these components with the rest of the detector apparatus and commissioning the detector systems using energetic elementary particles coming from cosmic rays. The LHC is expected to begin accelerating protons in late FY 2008, after which the detector commissioning will proceed using the elementary particle fragments arising from proton-proton collisions. This activity will continue into FY 2009. Data-taking is expected to begin

This image shows the CMS detector at the European Organization for Nuclear Research (CERN). The detector is 15 m diameter, 21.5 m long and weighs about 12,500 tons.

in FY 2009 when the beam performance stabilizes. The LHC is expected to operate until approximately 2016, at which time an upgrade to increase the luminosity by a factor of 10 is anticipated, extending operation of the facility well into the following decade.

NSF currently supports the detector commissioning and operations through a cooperative agreement with the ATLAS and CMS collaborations, for the period FY 2007-2011. Before the expiration date, it is expected that a new proposal to support the continuing operation of the LHC detectors for the period FY 2012-2016 will be submitted.

Partnerships: NSF contributed to the construction of both of the large general-purpose detector experiments located at the LHC, ATLAS and CMS, and is now involved in their maintenance and operation. These detectors have been built to characterize the different reaction products produced in the very high-energy proton-proton collisions that will occur in interaction regions where the two counter-circulating beams collide. A total of 41 international funding agencies participate in the ATLAS detector project, and 37 participate in the CMS detector project. NSF and DOE are providing U.S. support. CERN is the management entity responsible for integrating this world-wide effort and meeting the goals of the international LHC project.

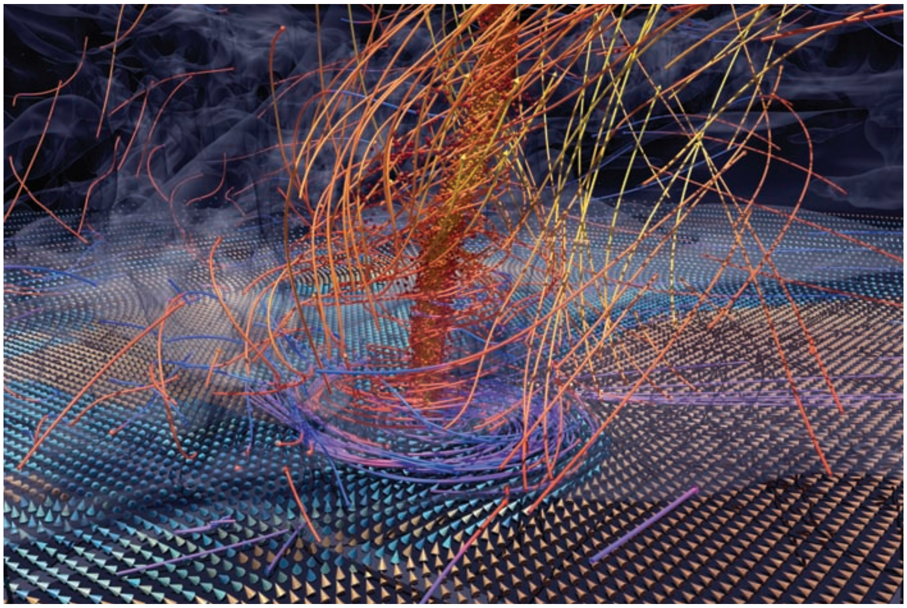
NSF Role: Programmatic oversight is the responsibility of the NSF Program Director in MPS/PHY. U.S. LHC program management is performed through a Joint Oversight Group (JOG) created by the NSF and DOE. The JOG has the responsibility to see that the U.S. LHC Program is effectively managed and executed to meet commitments made under the LHC International Agreement and its Protocols. 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 the overall program management.

NSF currently provides operations and maintenance support of approximately \$18 million per year from the MPS/PHY R&RA account through FY 2011.

More information about the ATLAS and CMS detectors can be found at http://atlasexperiment.org/ and http://cms.cern.ch/ respectively. There is more information about the overall LHC project available at http://lhc.web.cern.ch/lhc/.

BLUE WATERS: A leadership-class computing system

Facility Objectives: Blue Waters is being designed to be the world's most powerful "petascale" system for science and engineering research, capable of making arithmetic calculations at a sustained rate in excess of 1,000-trillion operations per second. This leadership class computing system will provide unprecedented computing resources to enable the next generation of science and engineering applications, those that use multiple models at multiple scales to describe complex processes. The system will help investigators advance studies of some of the world's most challenging science and engineering research problems, such as the formation and evolution of galaxies in the early universe; the interaction of the Sun's coronal mass ejections with the Earth's magnetosphere and ionosphere; the chains of reactions that occur with living cells, organs, and organisms; and the design of novel materials. Other applications that may be possible include developing next generation climate models, carrying out sophisticated neuroscience simulations, large-scale economic modeling, and designing models for



This visualization, created from data generated by a tornado simulation calculated on the NCSA computing cluster, shows the tornado by spheres colored according to pressure. Orange and blue tubes represent the rising and falling airflow around the tornado. NCSA's Blue Waters facility will be able to detail even more complex simulations.

predicting the impact of hurricanes including the effect of storm surge.

The Blue Waters system will be sited at the University of Illinois at Urbana-Champaign (UIUC) where it will be operated by the National Center for Supercomputing Applications (NCSA) and its partners in the Great Lakes Consortium for Petascale Computing (GLC).

The system will have a major impact on the preparation of a new generation of learners, providing hands-on research and other opportunities to scientists, teachers, students and businesses to help them gain the skills required to make effective use of high performance computing in academia and in industry.

The Blue Waters system is expected to go online in 2011 and have an anticipated operational lifetime of at least five years.

Status: In August 2007, the NSB approved $208 million from the Office of Cyberinfrastructure (OCI) R&RA account for the acquisition of Blue Waters, and a grant was made in September 2007. The first phase of the project consists of the finalization of the draft contract with the primary vendor, finalization of statements of work with other partners, and contracting with an engineering firm for the final design of the building being built by UIUC to house the facility. The building engineering design contract has been approved by the UIUC Board of Trustees. The contract with the primary vendors and the finalized statements of work for the project partners will be externally reviewed in February 2008. UIUC anticipates awarding the acquisition contract to the primary vendor in Spring 2008.

Partnerships: NSF's OCI is providing the funds for system acquisition, and anticipates providing operations and maintenance costs, including user support, for the period FY 2011-2015. UIUC is providing the building to house the system. Over the next three years, UIUC and its GLC partners will work with research groups planning to use the Blue Waters system to help them prepare their numerical codes to run efficiently at scale on Blue Waters, prior to its deployment. With funding of its own, UIUC is acquiring a precursor system for use in application software development.

NSF's Role: Programmatic oversight is the responsibility of the High-Performance Computing (HPC) program director, located in OCI.

Software and hardware functionality will be delivered in phases. The project has major milestones and associated deliverables scheduled every six months. Acceptance criteria for the deliverables are specified in the project plan. At most major milestones, NSF will assemble a panel of external experts to assist in evaluating the awardee's report of performance on the milestones and to provide advice on the conduct of the project. In addition to the review of the acquisition contract with the primary vendor and sub-awardee statements of work, the first Milestone Review will also include a review of the awardee's updated Project Execution Plan (PEP), project management structure and updated risk mitigation plans.

NSF has also issued a solicitation for requests for allocations of Blue Waters resources. These requests will be reviewed by a panel of external experts convened by NSF.

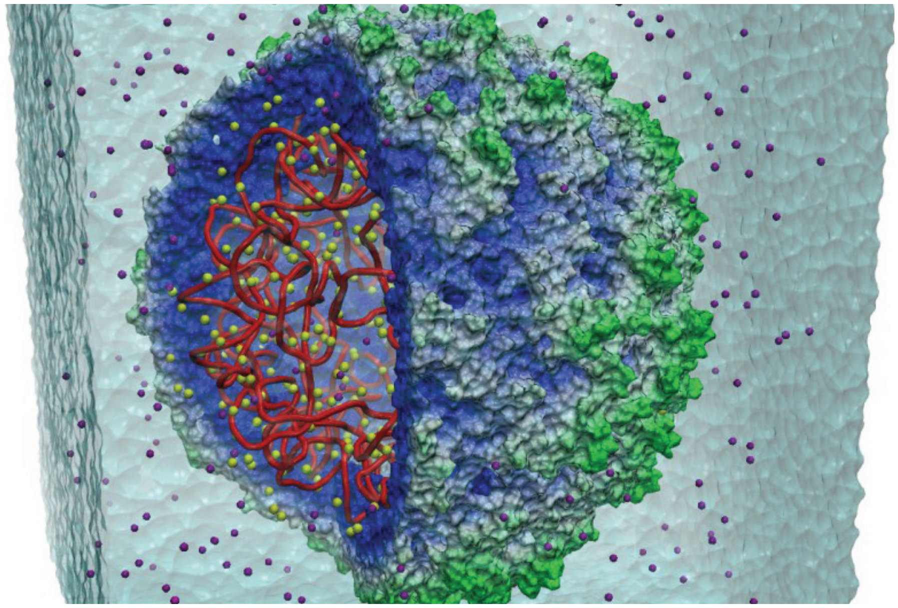
NSF expects to provide annual funding of approximately $30M to support operation and maintenance of the Blue Waters system, beginning in FY 2011.

More information on the Blue Waters project is available at http://www.ncsa.uiuc.edu/BlueWaters/.

NATIONAL INSTITUTE FOR COMPUTATIONAL SCIENCES (NICS)

Facility Objectives: The National Institute for Computational Sciences (NICS) is NSF's recently awarded high-performance computing system acquisition project. If petascale computing is the gold standard for the next generation academic cyberinfrastructure, this mid-range high performance system will move U.S. researchers toward that goal, providing peak performance of just under one petaflop, which is nearly four times the capacity of the TeraGrid at the end of 2007. The NSF-supported Teragrid is currently the world's most powerful and comprehensive distributed cyberinfrastructure for academic science and engineering research. The new near-petascale system's computing capability will significantly expand the capacity of the Teragrid and enable investigators to pursue breakthrough science and engineering research in a wide range of computationally demanding areas including: life sciences, Earth, atmospheric and ocean sciences, chemistry and biochemistry, materials research and nanoscale engineering, computational fluid dynamics, high-energy physics, astronomy and astrophysics, space physics, economics, neuroscience and social science.

NICS is led by the University of Tennessee at Knoxville (UTK) in collaboration with the Oak Ridge National Laboratory (ORNL). They will acquire, deploy and operate a sequence of large, well balanced, high-performance computational resources on behalf of the science and engineering research community. Initially, a



Researchers at the University of Illinois at Urbana-Champaign completed the first all-atom simulation of satellite tobacco mosaic virus. The next facility will be capable of even more complex simulations.

170-teraflops Cray XT4 system will be deployed. This will subsequently be upgraded to a Cray "Baker" system of nearly one petaflop.

NICS's anticipated operational lifetime is at least four years.

Status: The award for NICS was approved by the NSB in August 2007 and implemented in September 2007. The first phase of the project consisted of the finalization of the draft contract with the primary vendor and the refinement of the Project Execution Plan. These were reviewed in November 2007. Minor changes in the contract terms were requested by NSF and the revised draft contract was submitted for approval by NSF's Division of Grants and Agreements in December 2007. It is anticipated that UTK will formalize the contract with Cray Inc. in Winter 2008.

Partnerships: OCI is providing the funds for system acquisition, together with operations and maintenance costs, including user support, for the period 2008-2011. DOE's Office of Science is funding ORNL to acquire similar, but not identical, computing systems for DOE use. NSF and DOE are coordinating their oversight of these projects to ensure adequate staffing and management arrangements are in place at ORNL and to ensure that lessons learned in the deployment are rapidly shared between the two projects.

NSF's Role: Programmatic oversight is the responsibility of the HPC program director, located in OCI.

The computing systems and their associated software will be delivered in phases. The project baseline includes several major milestones, most of which are associated with specific deliverables. Acceptance criteria for the deliverables are specified in the project plan. At most major milestones, NSF will assemble a panel of external experts to assist it in evaluating the awardee's report of performance on the milestones and to provide advice on the conduct of the project. Allocations of NICS resources will be determined by the project team based on advice from the TeraGrid's Resource Allocation Committee, a group of experts in computational science who are not part of the TeraGrid project. Allocation decisions are subject to review by NSF. During the operations phase, the science and engineering research achievements and general progress of the project will be reviewed annually. A User Committee will provide regular input to the awardee on operational issues.

The award includes funding of approximately $8.6M on an annualized basis to support operation and maintenance of NICS, beginning in FY07.

More information about NICS can be found at http://www.jics.utk.edu/nics/.

RANGER: A high-performance computing system for science and engineering

Facility Objectives: Ranger is the new high performance computing system being deployed at the Texas Advanced Computer Center at the University of Texas at Austin. Together with NICS, Ranger is part of NSF's four-year initiative to fund the deployment and operation of leading-edge systems to greatly increase the availability of computing resources to U.S. researchers, and reverse the relative decline in academic capabilities for high performance computing. The new system provides the first petascale computing platform based within the U.S. university research community, with peak performance of one-half petaflop per second. Ranger is specifically designed to provide unprecedented power to support very large science and engineering computational requirements. The system will enable investigators to pursue computationally demanding problems in a broad range of disciplines including biology, Earth sciences, certain fields of engineering, the behavioral and social sciences, elementary particle physics, and astrophysics. It also will provide groundbreaking opportunities for advancing important areas of computer science research, such as the development of parallel algorithms, fault tolerance, scalable visualization, and next-generation programming languages.

Ranger triples the computational capacity of the TeraGrid. In its final configuration, Ranger will have a peak performance of some 504 teraflops. The system architecture includes an unusually large total system memory. With 125 terabytes of memory and 1.7 petabytes of raw disk storage, Ranger makes possible very data-intensive and memory-intensive calculations.

In January 2008, Ranger was operational in "friendly user" mode, and it is scheduled to transition to normal operations at the beginning of February 2008. The anticipated operational lifetime after deployment is at least four years.

Status: Ranger was deployed through a collaboration between the University of Texas at Austin and Sun Microsystems. The award to the University of Texas was approved by the NSB in August 2006 and made in September 2006. The first phase of the project consisted of the finalization of the draft contract with the primary vendor and the refinement of the Project Execution Plan. The distribution of power and cooling in a new computer room was completed and the system hardware was delivered and installed. Testing of various software components and hardware sub-systems has proceeded in stages, overlapping

The "Ranger" supercomputer at the Texas Advanced Computer Center (TACC) will provide unprecedented computational capabilities—504 teraflops peak performance, 125 terabytes memory and 1.7 petabytes disk—to the national open science research community. This system represents a unique opportunity to explore the challenges of petascale science from science and technology perspectives.

with system build-out. Early users gained access to the system in early December 2007 for the traditional "friendly user" period of system testing.

It is anticipated that acceptance testing will be completed in January 2008 and the system will formally enter production status at the beginning of February 2008. User time will be available for normal allocation at the March 2008 Resource Allocation Committee meetings. Until then, several early user groups intend to exploit their access to this large, new resource for research in fifteen areas including: climate science, cosmology, space physics, lattice-gauge quantum chromodynamics, computational fluid dynamics, ocean science, Earth science, and molecular biology.

Partnerships: OCI is providing the funds for system acquisition, together with operations and maintenance costs, including user support and training, for the period 2008-2011. Arizona State University and Cornell University are assisting with training and outreach activities.

NSF's Role: Programmatic oversight is the responsibility of the HPC program director, located in OCI. NSF conducted an external review of progress in July 2007.

The project is proceeding in phases with specific deliverables. These are associated with milestones in the project baseline. Increases in spending authority are tied to successful completion of milestones. Acceptance criteria for the deliverables are specified in the project plan and in the contract between Sun and the University of Texas. When the acceptance conditions for a phase are met, the University of Texas certifies this and provides NSF with the data from the acceptance tests for review.

Upon completion of final acceptance testing in January 2008, NSF will reassemble the panel of external experts for an evaluation of the acceptance test results. During the operations phase, the science and engineering research achievements and general progress of the project will be reviewed annually. A User Committee will provide regular input to the awardee on operational issues. Ranger allocations will be determined by the project team based on advice from the TeraGrid's Resource Allocation Committee, a group of experts in computational science who are not part of the TeraGrid project. These are subject to review by NSF.

The award includes funding of approximately $7.25 million on an annualized basis to support operation and maintenance of Ranger, beginning in FY07.

More information about Ranger is available at http://www.tacc.utexas.edu/resources/hpcsystems/ and http://www.tacc.utexas.edu/research/users/features/alcalde.php/.

APPENDIX I: PLANNING AND OVERSIGHT OF MAJOR RESEARCH EQUIPMENT AND FACILITIES CONSTRUCTION (MREFC) PROJECTS

Many fields of scientific inquiry require capital intensive investments in major research infrastructure to maintain or advance their capabilities to explore the frontiers of their respective disciplines. Facility needs are projected to emerge in additional areas in the future, adding further emphasis to the need for NSF to develop a management culture that is adept at planning, building, and operating large facilities. To achieve this goal, NSF continuously assesses its effectiveness in this area, and it has taken a number of actions over the last two years to improve its performance and capabilities:

- With the advice of expert external advisory committees, NSF substantially revised its procedures for planning and constructing new facilities funded through the MREFC account, and released these procedures for use in December 2005 as the "Guidelines for Planning and Managing the MREFC Account."

- NSF augmented the staff of the Large Facilities Office, located within NSF's Office of Budget, Finance, and Award Management, to assist the Foundation in implementing these Guidelines through activities such as: organizing and analyzing reviews, conducting site visits, and advising NSF at all levels on project management issues.

- After further internal and external assessment, NSF updated these guidelines and incorporated them into a broader document, the Large Facilities Manual[6], released in May 2007.

The 2007 Large Facilities Manual describes, in detail, the current coordinated process that synchronizes the development of a possible future facility's technical design and budget development with NSF's oversight planning and prioritization activities. This process is summarized below:

PROCESS FOR DEVELOPMENT

MREFC-funded construction projects proceed through a progressive sequence of increasingly detailed development and assessment steps prior to approval for construction funding. Initially, NSF reacts to opportunities articulated and advocated by the research community during the earliest stage of consideration. These ideas are subjected to external merit review, and those ideas or concepts of exceptional merit are further developed into conceptual designs that define the key research questions the proposed facility is intended to address.

For the most promising projects, NSF encourages proponents to develop conceptual designs that include the definition and relative prioritization of the research objectives and science questions that the proposed facility will address; a comprehensive statement of the science requirements to be fulfilled by the proposed facility, which establish a basis for determining the project's design goals and infrastructure requirements; and descriptions of the functional requirements of the major subsystems of the proposed facility that are essential to achieve the research objectives. These are accompanied by a top-down budget estimate; a risk assessment and the corresponding contingency budget needed for risk mitigation; a projection of future partnerships possible during further development, construction or operation; and an estimate of the future budget needed to operate the proposed facility. Concurrently, NSF develops an Internal Management Plan that defines its strategy for conducting oversight during more intensive pre-construction planning, and also for funding this activity and providing off-ramps should project development not progress as planned. NSF then conducts a Conceptual Design Review (CDR). If the project is selected by NSF for more intensive development and planning, NSF requests proponents to provide a Project Development Plan (PDP) that details the scope, schedule and budget needed to develop the project's Preliminary Design. At this point, if NSF approves the PDP, this activity is carried out in the "Readiness Stage."

The goal of the Readiness Stage is to identify and quantify all of the key cost drivers associated with the proposed project into a Preliminary Design, providing detailed descriptions of all major facility subsystems and their interconnections, a bottom-up cost estimate with

6 NSF 07-38 , available on-line at http://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf0738.

substantiation for the basis of the estimate, a detailed risk assessment and algorithmically based contingency estimate, and a resource loaded schedule. The project also assembles key members of the team that will build the proposed project if it is funded for construction. NSF, utilizing external experts having the requisite skills to assess all of the major elements of the construction plan, reviews the Preliminary Design in a Preliminary Design Review (PDR). If NSF approves the Preliminary Design, it requests NSB to approve the project's inclusion in a future NSF Budget Request to Congress. Should the NSB approve, the project is classified as a Possible New Start.

While in this stage, the project team continues to refine cost estimates, recruit additional construction staff, finalize partnership commitments, and complete other preparatory work that must be accomplished prior to commencing construction. A final pre-construction design is prepared and reviewed by NSF, using the same rigor as the PDR. If successful, NSB is requested to authorize NSF to obligate funds to the proponents to commence construction. Projects in this category are in the Construction Stage.

Following construction and commissioning of the new facilities, or in many cases concurrently with those activities, operation begins. In most cases, the entity responsible for constructing and commissioning the facility also has responsibility for initial operation. NSF is responsible for encouraging excellence and efficiency in facility operation, and it does this by encouraging full and open recompetition of the subsequent award for continued operation and maintenance. In addition to creating incentives for excellence and efficiency, this insures that the operating awardee is appropriately sensitive to the needs and satisfaction of the user community, and that the awardee will work collaboratively with NSF and the user community to maintain and advance the capabilities of the facility in accordance with a shared vision of future opportunities.

CONTINUOUS PROCESS IMPROVEMENT

NSF continues to look for ways to improve the effectiveness of its oversight of its large facilities. For example, in 2006, the Large Facilities Office assumed responsibility for conducting facility Business Systems Reviews. Business Systems Reviews ensure that the administrative systems used by awardees currently operating large facilities fully satisfy NSF's expectations and comply with 2 CFR 215.[7] Five Business Systems Reviews have been conducted so far, and all operating large facilities will be reviewed at least once within the period of their current operating awards. Also, supplementary materials that elaborate on the information contained in the Large Facilities Manual are under development and are expected to be released for general use in 2008.

In 2007, NSF organized an internal working group to look at additional ways to strengthen project selection and prioritization, how to most effectively provide resources for pre-construction planning and future operation and research utilizing the facility in question, and how best to insure that the operation of existing facilities is carried out in the best interests of U.S. science and engineering research and education. This activity is part of a broader discussion that is ongoing with the National Science Board, the Office of Management and Budget, and the broad community of researchers supported by NSF. Further refinement of NSF's policies and procedures are expected as a result of these efforts.

7 Code of Federal Regulations, Title 2 – Grants and Agreements, Part 215 – Uniform Administrative Requirements for Grants and Agreements with Institutions of Higher Education, Hospitals, and Other Non-Profit Organizations (OMB Circular A-110); available on-line at: http://www.access.gpo.gov/nara/cfr/waisidx_05/2cfr215_05.html.

APPENDIX II: GLOSSARY OF ACRONYMS

AdvLIGO Advanced Laser Interferometer Gravitational Wave Observatory
ALMA Atacama Large Millimeter Array
ARRV Alaska Region Research Vessel
AST Division of Astronomical Sciences
ATM Division of Atmospheric Sciences
ATLAS A Toroidal LHC ApparatuS
ATST Advanced Technology Solar Telescope
AUI Associated Universities, Inc.
AUV Autonomous Underwater Vehicle
AURA Association of Universities for Research in Astronomy, Inc.
BIO Directorate for Biological Sciences Caltech California Institute of Technology
CDR Conceptual Design Review
CERN European Organization for Nuclear Research
CMS Compact Muon Solenoid
CTIO Cerro Tololo Interamerican Observatory
DBI Division of Biological Infrastructure
DOE Department of Energy
DOM Digital Optical Module
EAR Division of Earth Sciences
ESO European Southern Observatory
ETS Episodic Tremor and Slip
FDR Final Design Review
GEO Directorate for Geosciences
GEOSS Global Earth Observation System of Systems
GLC Great Lakes Consortium for Petascale Computing
GPS Global Positioning System
HPC High-Performance Computing
IODP Integrated Ocean Drilling Program
IOFG International Oversight and Finance Group
IRIS Incorporated Research Institutions for Seismology
KIGAM Korea Institute of Geoscience and Mineral Resources
KPNO Kitt Peak National Observatory
LHC Large Hadron Collider Detectors
LIGO Laser Interferometer Gravitational-wave Observatory
LSC LIGO Scientific Collaboration
MMA Millimeter Array
MEXT Ministry of Education, Culture, Sports, Science and Technology (Japan)
MIT Massachusetts Institute of Technology
MOST Ministry of Science and Technology (China)
MOU Memorandum of Understanding
MPS Directorate for Mathematical and Physical Sciences
MREFC Major Research Equipment and Facilities Construction
NAIC National Astronomy and Ionosphere Center
NASA National Aeronautics and Space Administration
NCAR National Center for Atmospheric Research
NCSA National Center for Supercomputing Applications
NEON National Ecological Observatory Network
NHMFL National High Magnetic Field Laboratory
NICS National Institute for Computational Sciences
NOAA National Oceanic and Atmospheric Administration
NOAO National Optical Astronomy Observatory
NRAO National Radio Astronomy Observatory
NRC National Research Council
NSB National Science Board
NSF National Science Foundation

NSO National Solar Observatory
O&M Operations and Maintenance
OCE Division of Ocean Sciences
OCI Office of Cyberinfrastructure
OMB Office of Management and Budget
ONR Office of Naval Research
OOI Ocean Observatories Initiative
OPP Office of Polar Programs
ORNL Oak Ridge National Laboratory
OSTP Office of Science and Technology Policy
PBO Plate Boundary Observatory
PDP Project Development Plan
PDR Preliminary Design Review
PEP Project Execution Plan
PHY Division of Physics
PM Photomultiplier
R&D Research and Development
R&RA Research and Related Activities
REU Research Experiences for Undergraduates
SAFOD San Andreas Fault Observatory at Depth
SODV Scientific Ocean Drilling Vessel
SPSM South Pole Station Modernization
UAF University of Alaska, Fairbanks
UIUC University of Illinois at Urbana-Champaign
USAF United States Air Force
USDA United States Department of Agriculture
USGS United States Geological Survey
UTK University of Tennessee at Knoxville
VLB Very Long Baseline Interferometry

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Cover Design	Adrian Apodaca, National Science Foundation

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Design by: Adrian Apodaca, National Science Foundation