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Mission Statement
The National Optical Astronomy Observatory (NOAO) is the US national research and development center for ground-based nighttime astronomy. In particular, NOAO is enabling the development of the US Ground-based Optical-Infrared (O/IR) System (the System), an alliance of public and private observatories allied for excellence in scientific research, education, and public outreach.

The core mission of NOAO is to provide public access for qualified professional researchers, via peer review, to forefront scientific capabilities on telescopes operated by NOAO and other telescopes within the System. Today, these telescopes range in aperture size from 2- to 10-m. NOAO is participating in the development of telescopes with aperture sizes of 20 m and larger as well as a unique 8-m telescope (the Large Synoptic Survey Telescope) that will make a 10-year movie of the Southern Hemisphere sky.

In support of this mission, NOAO is engaged in programs to develop the next generation of telescopes, instruments, and software tools necessary to enable exploration and investigation throughout the observable Universe, from planets orbiting other stars to the most distant galaxies in the Universe.

To communicate the excitement of such world-class scientific research and technology development, NOAO has developed a nationally recognized Education and Public Outreach (EPO) program. The main goals of the EPO program are to inspire young people to become explorers in science and research-based technology and to reach out to groups and individuals who have been historically underrepresented in the physics and astronomy science enterprise.

The Association of Universities for Research in Astronomy (AURA) operates NOAO under a cooperative agreement with the National Science Foundation (NSF).
1 Introduction

1.1 Overview
This is the NOAO Long-Range Plan (LRP) for FY 2009–2013.

NOAO has recently undergone a period of vigorous community review and discussion about its current mission and future direction. From these reviews, a vision has emerged of NOAO as a dynamic national center with a broad, complex, and scientifically exciting mission. Key vision documents from external groups are listed at the end of this section.

The long-range plan described here responds to that vision by defining NOAO high-level deliverables and how NOAO will be organized and funded to make those deliverables possible. This plan will be updated annually. Detailed planning at the work package level is provided yearly in the NOAO Annual Program Plan.

1.2 High-level deliverables: highlights

1.2.1 NSF base funding
From NSF base funding support, NOAO plans to deliver and/or enable:

- Operation of NOAO facilities on Kitt Peak (Mayall 4-m, WIYN 3.5-m, 2.1-m)
- Operation of NOAO facilities in Chile (Blanco 4-m, SOAR 4.2-m)
- Support services for tenant observatories on Kitt Peak and Cerro Tololo
- Support services for the US Gemini science user community
- Delivery of ground-layer adaptive optics system with high spatial resolution imager for SOAR 4.2-m
- Design and development activity for the Large Synoptic Survey Telescope (LSST) including telescope systems and on-site support facilities
- Community engagement in the Giant Magellan Telescope (GMT) and Thirty Meter Telescope (TMT) development, especially in areas of science capability and operations requirement definition
- Science data management services that are focused on immediate NOAO needs
- Education and Public Outreach program that is focused on critical local activities/needs while maintaining a national (global) perspective through innovative programs
- Technical support and program management required for instrumentation development funded through supplementary budget allocations
- Administrative and facility operations services necessary for an organization with more than 300 employees at two geographically distributed sites
The ALTAIR committee recommended that NSF work to make more nights available to the US community-at-large while working with the international Gemini partnership to enhance capabilities for all users. Obtaining more nights is not an NOAO deliverable (from base or supplementary funding), but supporting the users of those nights would be.

### 1.2.2 NSF supplementary funding

From NSF supplementary funding support, NOAO plans to deliver and/or enable:

- Major deferred maintenance catch-up and infrastructure improvement program (stimulus funding)
- Annual REU programs in Tucson and La Serena
- At least one (1) PAARE partnership in Tucson
- New medium-resolution optical spectrographs for Mayall and Blanco telescopes (ReSTAR Phase 1)
- New medium-resolution near-infrared spectrograph for Blanco (ReSTAR Phase 1)
- New optical echelle spectrograph for Discovery Channel Telescope (ReSTAR Phase 1)
- Community-access to Palomar Hale 5-m (ReSTAR Phase 1)
- Continued instrumentation development support for non-NOAO 6- to 10-m facilities in return for community access (TSIP)

### 1.3 NOAO strategic vision: background documents

For easy reference, this sub-section lists recent documents that inform the NOAO strategic vision implemented in this LRP.

- 2006 Senior Review, NSF AST Facilities, final report
  
  [www.nsf.gov/mps/ast/ast_senior_review.jsp](http://www.nsf.gov/mps/ast/ast_senior_review.jsp)

- ReSTAR committee, final report
  
  [www.noao.edu/system/restar](http://www.noao.edu/system/restar)

- ALTAIR committee, final report
  
  [www.noao.edu/system/altair](http://www.noao.edu/system/altair)

- AURA Future of NOAO committee, white paper
  
  [www.noao.edu/system/future09](http://www.noao.edu/system/future09)

- AURA Decadal Survey committee, final report
  
2 High-level LRP development framework

2.1 Budget status: early April 2009

At the time of this writing, the future of the NOAO budget is still uncertain because: (1) stimulus funding for NOAO has not yet been finalized; (2) the NOAO FY 2009 budget allocation is still not final; (2) the official NOAO FY 2010 budget request has not been released; and (3) the evolution in the participation of NOAO in the Gemini, TSIP, LSST, and GSMT programs is still unclear.

In order to make progress, the following assumptions have been made for the planning period FY 2009–2013:

- Per recent conversations with NSF, stimulus funding is expected to be “several million” but restricted to deferred maintenance and infrastructure improvement catch-up activities. Stimulus funding will not be available for funding instrument or other science capabilities. Stimulus funding is a one-time event that will allow NOAO to fix point-problems (e.g., aging water treatment plants on Kitt Peak and Cerro Tololo) and reduce long-term facility maintenance cost stress on the NOAO base budget.
- NOAO base funding will start at the FY 2009 President’s Request level ($27.7M) and increase at 3% per year.\(^1\)
- The ReSTAR Phase 1 implementation proposal will be completely funded (see below). Phase 2 and 3 proposals will be submitted in FY 2011 and FY 2013 (dates tentative).
- The current relationship between NOAO and Gemini will continue unchanged.
- TSIP funding will continue at the $3–5M per year level, and may increase to the $10M level.
- The Large Synoptic Survey Telescope (LSST) project will remain a major NOAO activity during this planning period, initially in the area of design and development (FY 2009 – 2011). A construction start in FY 2012 or FY 2013 is not impossible but depends on the recommendations from the 2010 decadal survey and available funding. Likely NOAO roles in LSST construction and operations are already loosely defined and will be finalized in the next 24 months.
- NOAO will continue to act as the NSF Giant Segmented Mirror Telescope (GSMT) program manager.

\(^1\) While this is consistent with the recently approved cooperative agreement between AURA and NSF for the management of NOAO as well as early 2009 direction from NSF, it now (April 2009) seems unlikely that the actual FY 2009 and FY 2010 budget allocations will be consistent with this assumption. Unless this situation improves, NOAO faces continued base program challenges ahead. See Section 5 for further discussion.
• The number of NOAO staff supported by the base budget will grow by less than 5% during this planning period (approximately no more than 15 positions across all NOAO skill sets and divisions). However, short-term (1–5 years) staff may be hired using supplementary funding for specific programs (e.g., ReSTAR, LSST, GSMT).

2.2 Strategic principles
During the review of the recent AURA cooperative agreement renewal proposal, the National Science Board (NSB)/NSF underscored that the highest priorities for NOAO are as follows:

• In partnership with other private and public observatories, develop an open-access US system of ground-based facilities that spans the 2- to 10-m range of telescope aperture size and includes a balanced suite of scientific capabilities. As part of that US system, NOAO will continue operation of Kitt Peak National Observatory (KPNO) and Cerro Tololo Inter-American Observatory (CTIO) at a robust level until at least 2020.

• Enhance that US system through participation in the development of new major facilities such as LSST and GSMT. NOAO participation can come in several ways, but the main goal is to assure that the requirements of the community-at-large are satisfied by whatever major facilities seek NSF funding and later reach fruition.

• Broaden participation in the NSF science enterprise by engaging individuals, institutions, and geographical areas “that do not participate in NSF research programs at rates comparable to others.”

• As opportunities arise, leverage NSF investment by using funding from other Federal agencies (e.g., DOE, NASA) or private sources to enable high-impact science capabilities and/or projects.

Within the overall NOAO program, CTIO and KPNO must have the highest priority. NOAO must not lose ground gained in the last 24 months in implementing the 2006 Senior Review priorities.

The most important future initiative for NOAO remains LSST. NOAO involvement in that project must be protected. Even if LSST fails or NOAO needs to withdraw, the engineering talent assigned to that program is crucial to the future of NOAO. Losing key engineering and technical staff members likely would make it impossible for NOAO to participate in a major instrumentation or facility development project during the next five years or longer.

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2 From Executive Summary, Broadening Participation at the National Science Foundation: A Framework for Action, August 2008.
3 A recent example is the Dark Energy Survey (DES)/Dark Energy Camera (DECam) project funded primarily by DOE. See www.darkenergysurvey.org/
Although NOAO acts as NSF GSMT program manager, direct NOAO involvement in the Giant Magellan Telescope (GMT) and Thirty Meter Telescope (TMT) projects will remain limited unless new additional funding becomes available. Starting construction of GMT and/or TMT during or soon after FY 2012 is not impossible but depends on the recommendations from the 2010 decadal survey and available funding. An NOAO role in GMT and/or TMT construction and operations is highly desirable but currently undefined. Clarification of this issue is a major task for this LRP period.

2.3 ReSTAR: Renewing Small Telescopes for Astronomical Research

In partial response to the recommendations of the 2006 Senior Review of NSF astronomy facilities, NOAO organized an external committee to review current and future capabilities across the US O/IR System for facilities with apertures less than 6 m. The ReSTAR committee surveyed the entire community and distilled a wide range of input. In their report, they described the excellent scientific research enabled by 2- to 5-m telescopes and made prioritized recommendations about upgrading infrastructure at facilities, improving science capabilities, and increasing access to telescopes in this aperture range.4

NOAO has embarked on a long-term program to implement these recommendations. This program will be supported from the NOAO base budget (e.g., administration, engineering, and technical support) but primarily funded by supplementary NSF grants.

A proposal to NSF for the first three years of this program is currently under review. This so-called ReSTAR Phase 1 proposal requests funds to complete the following tasks:

- Fund infrastructure improvement projects at NOAO and non-NOAO facilities.
- In collaboration with The Ohio State University, build two copies of OSMOS, a medium-resolution optical spectrograph. One copy will be deployed at the KPNO Mayall 4-m and one at the CTIO Blanco 4-m.
- In collaboration with Cornell University, build one copy of TripleSpec, a moderate-resolution near-IR spectrometer and deploy it at the CTIO Blanco 4-m. If base or supplementary funding permits, a second copy of TripleSpec will be built for the KPNO Mayall 4-m.
- Complete development, design, and construction of a new optical echelle spectrograph for the Discovery Channel Telescope. Construction funding awaits ReSTAR Phase 2 or other funding sources.
- Create graduate student instrumentation internships for each instrument project funded by the ReSTAR proposal.

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4 The ReSTAR final report is available online from [www.noao.edu/system/restar](http://www.noao.edu/system/restar).
• Obtain access to 50 or more nights per year at the Palomar Hale 5-m for the community-at-large, in particular for access to existing medium-resolution optical and near-IR spectrographs.

• Obtain access to circa 100 nights per year for the community-at-large at the Discovery Channel Telescope.

• Complete design and development work for 2-m class telescopes for the Las Cumbres Observatory Global Telescope Network (LCOGTN) project. Construction funding awaits ReSTAR Phase 2 or other funding sources.

• If funding permits, undertake conceptual design studies for other capabilities, such as adaptive optics on small telescopes, and optical interferometry.

2.4 Partnerships with emerging international astronomy communities

The international astronomical landscape is changing. The US and Europe will see significant challenges for scientific leadership in the years ahead from emerging nations with growing economies and resources. These include the Russian Federation, People’s Republic of China, India, Brazil, and Republic of Korea. The Chinese presented an ambitious set of long-range goals across a wide range of ground-based astronomical disciplines/capabilities at the American Astronomical Society (AAS) winter meeting in Long Beach, California, in January 2009. A delegation of Indian astronomers recently visited NOAO to promote their expanded vision for O/IR telescopes and instruments in India and to explore potential collaborations with the US community.

The challenges presented by these emerging national communities also present opportunities for NOAO. International partnerships between one national entity and NOAO could be efficient and lead to rapid development of large-scale projects. In one case, at least, NOAO has already forged strong ties throughout the hierarchy of a potential partner: Brazil. NOAO and Brazil are both majority partners in the Southern Observatory for Astronomical Research (SOAR) telescope. NOAO has worked at all levels with Brazilian astronomers and technical staff in designing, fabricating, and operating state-of-the-art astronomical capabilities through the SOAR partnership. This includes hosting Brazilian engineers and post-docs for long term visits in La Serena in order to develop their talent pool as well as provide important operational support for SOAR. NOAO has also begun to build relationships with the Chinese and Korean ground-based communities. The coming decade could see mutually beneficial projects develop from these initial relationships.

This LRP does not suggest specific actions for developing such relationships, but NOAO must remain ready to take advantage of opportunities as they arise.

2.5 Cooperative agreement renewal assumptions and consequences

As a result of extensive discussions between AURA and NSF during the cooperative agreement proposal review period, significant NOAO structural changes are required in the next 24 months relative to the original renewal proposal.
In summary:

- Given the existence of higher priority programs, the proposed Public Affairs and Educational Outreach (PAEO) program has been reduced in scope to better match projected baseline resources. The reduced program has been renamed Education and Public Outreach (EPO).

- Similarly, the proposed Data Products Program has been reduced in scope. The reduced program has been renamed Science Data Management (SDM).

- The current NOAO Gemini Science Center (NGSC) will evolve into the NOAO System Science Center (NSSC). The NSSC will take over a variety of science operations tasks originally proposed for the System Division. Project scientists focused on LSST and GSMT as well as other major development projects will be hosted in the NSSC. The NSSC will also host the SDM group.

- Technology and instrument development related activities will be folded into an NOAO System Technology Center (NSTC) that will also encompass the existing System Instrumentation program, LSST Project Office, and Telescope System Instrumentation Program (TSIP) as well as small project offices for GSMT technology and ReSTAR implementation.

A number of other structural changes will be made to clarify lines of authority and responsibility with the intent of improving organizational efficiency. These are:

- A new Office of Science (OS) will be created to host and manage a variety of existing academic and research management activities under one senior scientist who reports to the NOAO Director.

- Already in existence informally for some years, the NOAO South operations center will be formally recognized. NOAO South manages site operations and/or provides operational support to a number of NOAO and allied facilities including CTIO, SOAR, Gemini South, the Small and Moderate Aperture Research Telescope System (SMARTS), and various other tenants. During this planning period, operational support for the LCOGTN 0.4/1.0-m platforms and construction support to LSST are expected to commence.

- As recently announced by AURA, NOAO South will absorb the existing AURA Observatory Support Services (AOSS) organization. Formal transfer of responsibility to NOAO South will be completed by the end of FY 2009. Detailed re-integration is expected to take at least another 12 months after that to complete.

- The GSMT Project Office will be put on hiatus until such time as significant federal investment for GSMT development, construction, or operations flows through NOAO. A GSMT Project Scientist will still exist within NSSC and GSMT-related technology development work will be supported by NSTC as funding permits.
• NOAO will explore the merger of Tucson downtown facilities and infrastructure support activities with the KPNO program to form an NOAO North umbrella organization with the same broad mountain/downtown mandate as NOAO South. Such a re-organization is not foreseen in the immediate future, to allow time to better understand how the downtown facilities may or may not evolve over the next 5–10 years.

Further structural changes may be necessary to respond to the outcome of the Astro2010 Decadal Survey, LSST and GSMT developments, etc. Such changes will be described in future LRP documents as necessary.
3 Program

3.1 Overview: NOAO and the US Ground-based O/IR System

The US Ground-based Optical-Infrared (O/IR) System (called “the System”) is a network of public and private observatories allied for excellence in scientific research, education, and public outreach. The System enables experimentation and exploration throughout the observable Universe for all scientists through peer review regardless of who they are or where they work. The System concept has gained support from participating institutions and has proven successful in attracting US federal resources from beyond the National Science Foundation.

The O/IR System concept emerged from the 2000 decadal survey and has gained increased acceptance in the broader community over the past five years, driven by the perceived success of the NSF-funded TSIP and closer coordination and engagement between NOAO and a wide range of other US-led observatories. Fundamental to the System concept is the use of federal money to fund new or improved science capabilities on facilities constructed and/or operated using non-federal money in return for those facilities providing nights for open community access.

![Figure 1: The US O/IR System](image)

Small images of the 3- to 10-m facilities that currently make up the US O/IR System.

The System concept was further endorsed by the NSF 2006 Senior Review report From the Ground Up: Balancing the NSF Astronomy Program. This report described an NSF Optical-Infrared Base program led by NOAO:

*The [NSF] Optical-Infrared Astronomy Base program should be led by the National Optical Astronomy Observatory. It should deliver community access to an optimized suite of high performance telescopes of all apertures through Gemini time allocation, management of the Telescope System Instrumentation Program and operation of existing or*
possibly new telescopes at Cerro Tololo Inter-American Observatory in the south and Kitt Peak National Observatory or elsewhere in the north. The balance of investment within the Base Program should be determined by the comparative quality and promise of the proposed science. In addition, there should be ongoing support of technology development at independent observatories through the Adaptive Optics Development and the Advanced Technologies and Instrumentation Programs.

In short, NOAO facilities are the open-access backbone of the public-private alliance that forms the US O/IR System. Furthermore, NOAO must provide the leadership necessary to develop the System for the benefit of all American astronomy and to facilitate open access via peer review to all of the System facilities.5

3.2 Top-level NOAO organization

In the rest of Section 3, all top-level NOAO programs are described and major program goals are provided. Where appropriate, the contribution of each program to the management, development, and/or operation of the US O/IR System is described.

Figure 2: Top-level NOAO organization

Names of top-level programs are shown in black. The corresponding senior manager is shown in blue.

3.3 NOAO South

3.3.1 Overview

The NOAO facilities located near La Serena, Chile continue to be the nucleus of US O/IR astronomy funded by NSF in the Southern Hemisphere. Cerro Tololo now hosts more than 15 telescopes and projects. Operations have expanded to neighboring Cerro Pachón, where both SOAR and Gemini-South are located and LSST will soon be built. Beyond operations of these telescopes, the NOAO South program is responsible for oversight and coordination of all NOAO activities in Chile, providing the broad range of administrative and technical resources and capabilities necessary to

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5 For a complete overview of the US O/IR System concept and status, see: www8.nationalacademies.org/astro2010/DetailFileDisplay.aspx?id=437
maintain the infrastructure and support the activities of the current observatories as well as future projects.

**Figure 3: Cerro Tololo**

An aerial view showing the NOAO Blanco 4-m as well as various facilities operated jointly with the SMARTS consortium.

As development began for the current generation of facilities (specifically SOAR and Gemini-South), CTIO planning focused on ensuring that a complementary set of facilities would be available (a “system within the System”). This local system included wide-field instrumentation on the Blanco 4-m telescope together with smaller-field, high image quality (IQ), blue-optimized instrumentation on SOAR and more red-optimized, high IQ instrumentation on Gemini-South. The blue-red optimization is broadly driven by the order of wavefront correction provided on a 4-m vs. 8-m aperture for atmospheric compensation. During this planning period, these efforts will culminate with the deployment of the 3-square-degree in area Dark Energy Camera (DECam) on the Blanco telescope together with the SOAR Adaptive-optics Module (SAM) on SOAR, complemented by the deployment of multi-conjugate adaptive optics enabled by laser guide stars on Gemini-South.

Recommendations from the ReSTAR and 2010 decadal survey reports will guide the next phase of NOAO South scientific development. Most importantly, NOAO South must plan for both the construction and operation of LSST, while also providing a set of facilities that supports the scientific investigation that the LSST engenders, including both imaging and spectroscopic exploration of the time domain as well as detailed studies of large samples of objects and smaller samples of outliers identified in the LSST dataset. Other major new survey imaging capabilities (e.g., DECam, Pan-STARRS, and the One Degree Imager) will further increase the need for timely spectroscopic follow-up of large numbers of sources. Monitoring of sources will become increasingly important as facilities like LSST revolutionize the use of observations of source variability to study the astrophysics of various populations of objects.
Imaging follow-up capabilities will be provided with such facilities as SMARTS, Blanco, SOAR, and Gemini, together with the LCOGTN, which plans to site a set of 0.4- and 1-m telescopes at CTIO. Demand for spectroscopic follow-up at the 4-m class level will be met by the planned ReSTAR spectrographs for the Blanco 4-m, one optical (OSMOS) and one near-IR (TripleSpec) (see Section 2.3).

In addition, NOAO has entered discussions with LCOGTN for the possible deployment of 2-m class telescopes on Cerro Tololo and Kitt Peak as enhancements to the 0.4/1.0-m network that LCOGTN is already deploying. A total of five 2-m class telescopes are planned, each with a common optical imaging spectrometer. Through NOAO, the US community-at-large would have up to 50% of the time on this network. Observations could be done on-site (classical mode), remotely, or through a queue-like strategy being developed by LCOGTN. In this LRP period, design and development activities will be completed jointly with LCOGTN if NSF supplementary funding is provided via the ReSTAR Phase 1 initiative. Actual construction of this 2-m network will require additional funding.

Finally, NOAO South provides a strong and stable infrastructure for this integrated system of complementary astronomical facilities. This foundation supports not only observatory-scale activities, but also serves as a platform for smaller programs such as NSF-funded projects like PROMPT, NASA-funded programs such as the Space Debris program on the University of Michigan Schmidt telescope, and private US programs such as Lowell Observatory. Although the infrastructure of NOAO South is currently solid, it is aging. We must pursue an aggressive campaign of infrastructure renewal and modernization in order to support ongoing and future activities.

### 3.3.2 Major activities

#### 3.3.2.1 Director’s Office

NOAO South is lead by an NOAO Associate Director, and is managed by a team that

![Figure 4: Cerro Pachón](image)

Aerial view of Cerro Pachón with Gemini South 8.2-m (foreground) and SOAR 4.2-m (background).
includes the CTIO Deputy Director and heads of the major units. The Director’s Office coordinates all NOAO activities in Chile, developing both strategic and operational plans and managing their implementation. Efficient operation and support for NOAO telescopes and supporting affiliated observatories (e.g., SOAR, Gemini) and tenants is the highest priority. The NOAO South Director’s Office also supports and oversees the scientific activities of NOAO in Chile, including support for visiting scientists using the facilities as well as support for staff scientists in their scientific endeavors.

3.3.2.2 Administration
The NOAO South Administration group, formerly the administrative portion of AOSS, is responsible for accounting and financial management, purchasing, shipping and receiving, and personnel activities. The group either performs these activities or provides legal oversight in these areas for all AURA units in Chile.

3.3.2.3 Facilities
The Facilities group supports and maintains the infrastructure upon which all of the observatories rely for operations. This infrastructure provides the operational services that must be provided by a common, centralized, service organization, including all activities dealing with maintaining the capability to support current and future programs at all major sites (La Serena, Cerro Tololo, and Cerro Pachón). Foremost of these activities is the maintenance and operations of the common infrastructure, including roads, power lines, water supply, and other utilities used by all programs and users. The group is also responsible for basic maintenance of all the buildings, including janitorial service, at all sites. In addition, the Facilities group provides shared services such as food, lodging, and transportation. Lodging includes not only operations of mountaintop dorms for visiting scientists, but also maintenance and operations of longer term housing for resident scientists in the La Serena AURA compound.

3.3.2.4 IT Services
The Information Technology (IT) group supports all NOAO computing and networking infrastructure in La Serena and on the two mountaintops, as well as the network connections between the sites and between Chile and the US mainland. This IT infrastructure is central to the operations of both NOAO and tenant telescopes, supporting activities including observation planning and scheduling, some remote observing, and data delivery to users and the NOAO Archive. The IT group also manages the recently installed Voice-over-Internet Protocol (VoIP) system, providing advanced telephone services at low cost to all of NOAO South and other users.

3.3.2.5 Engineering & Technical Services
The NOAO South Engineering & Technical Services (ETS) group provides both ongoing support for existing telescopes and instrumentation as well as active development of new instrumentation, upgrades to existing instrumentation, and development of improved subsystems for telescopes and instruments, from telescope control systems to detector controllers. Their historical knowledge of the instru-
ments and telescope systems, combined with their continual renewal of skills and tools needed for new projects, provides the necessary basis for optimal support of currently operational instrumentation as well as design and construction of new instrumentation.

3.3.2.6 Mountain Operations
Also called Telescope Operations (TelOps), the activities of this group focus on the night-to-night operations of the telescopes, including technical support and maintenance of the telescopes and instruments as well as scientific support for the visiting scientists using the facilities. This group provides both daytime support staff, including routine maintenance and instrument setup, and nighttime support staff, including telescope operators and on-call technical support for rapid resolution of most telescope and instrument problems.

3.3.2.7 Student programs, education, and public outreach
In coordination with the EPO program based in Tucson and other elements of efforts by NOAO to broaden participation of traditionally underrepresented groups, NOAO South pursues a strong suite of student programs along with education and public outreach activities. The student initiatives include an NSF-funded Research Experiences for Undergraduates (REU) program, complemented by a parallel initiative (Prácticas de Investigación en Astronomía) for Chilean undergraduates interested in astronomical research. Additional Chilean students are supported in an engineering and administrative internships program.

EPO efforts include a strong educational component, the current centerpiece of which is Centro de Apoyo a la Didáctica de la Astronomía (CADIAS), the Center for Support of Teaching of Astronomy. CADIAS serves both as a local community center with an astronomical theme (including hosting a small branch of the local municipal library and public Internet access) and as a nucleus of astronomical outreach activities, including training programs for local school teachers and training for municipal observatory staff. In addition to these educational programs, NOAO South EPO pursues an active public outreach program that includes participation and leadership in public events as well as a public visitor program to the CTIO telescopes on Saturdays.

3.3.3 Special topic: reintegration of AOSS into NOAO South
When construction of CTIO began in Chile in the 1960s, the observatory was established under the auspices and legal entity of AURA Observatory (or AURA-O) in Chile. The AURA-O legal entity now encompasses operations of all facilities on the AURA site, including CTIO, SOAR, and Gemini, and will cover operations of all future facilities that may be located on the AURA site.

In addition to providing the legal structure for resident programs, AURA-O currently supports the shared infrastructure of administration and facilities for the operations of the observatories through the AOSS program. Formerly part of CTIO, this group
was created as an independent entity in 2000 to provide services to the multiple observatories on site. AOSS provides local administration, including accounting, personnel (HR), shipping and receiving, and contracts support. It also operates and maintains the shared infrastructure of roads, support buildings, housing, and other facilities that are common needs of the observatories.

During the course of the recent review of AURA facilities operations, the review team noted that AOSS has no formal basis within any existing NSF cooperative agreement. Although the review team concluded that AOSS is performing well and in a cost-effective manner, the team also noted that a formal grounding in a cooperative agreement would provide greater transparency and oversight and would establish a sounder contractual basis for these important activities.

Therefore, AURA has decided to reintegrate AOSS into the NOAO cooperative agreement and direct NOAO South to execute all functions formerly assigned to AOSS. Furthermore, this reintegration provides NOAO South with the necessary experience and resources for the strategic development of infrastructure needed to support the growth of current and future programs (e.g., LSST).

This LRP covers a period of important expansion for the AURA/NOAO activities in Chile, including construction of large telescopes (e.g., LSST on Cerro Pachón) and smaller projects (e.g., Las Cumbres Observatory facilities on Cerro Tololo). During the initial year of this plan, AOSS must be successfully reintegrated into NOAO while continuing to provide high-quality facility services to all operational observatories.

As this transition is completed, NOAO must move quickly to capitalize on the AOSS integration to carry out a strong program of renewal and modernization to support not only the long-term ongoing operations of existing facilities but also the construction and operation of new facilities. This will require investment in infrastructure improvements, coordinated with new investments from future projects, to achieve a well-integrated operational solution.

Overlapping this renewal phase is a period of supporting facility construction, starting in late 2009 with the Las Cumbres Observatory facilities (three 1.0-m telescopes and support facilities) and quickly ramping up to support the construction of LSST beginning as early as 2010 through to commissioning in 2015.

Toward the end of this five-year plan, NOAO South will be providing ongoing operational support for a significantly expanded set of facilities. The challenge will be to provide high-quality support to observatories and smaller projects operating in a wide variety of modes, from classical observations to almost completely robotic operations.
3.3.4 Special topic: LSST development support

As the LSST development program continues through this LRP planning period, growing support will be required for activities at the planned telescope site on Cerro Pachón and the base facility site in La Serena. These activities fall into three general categories: (1) support for legal, contractual, and other Chilean relations; (2) support for site development and construction of the telescope; and (3) support for base facility development and construction, including important computing infrastructure.

During FY 2008 and FY 2009, two major legal milestones were achieved in the path toward LSST operations with AURA, AOSS, and NOAO support. The first was the signing of an agreement with Chilean representatives regarding the operations of LSST and Chilean astronomical community participation. The second was final approval from Chilean governmental authorities regarding the environmental impact of LSST construction and operations on Cerro Pachón. NOAO South, acting on AURA’s behalf through the integrated services of AOSS, executes all local legal and logistical activities required for the preparation for and operation of LSST. The NOAO South administrative and facilities groups will be providing this support, handling the Chilean end of shipping and receiving, importation, and transport of materials, as well as the legal aspects of contractual agreements for construction and personnel activities.

On Cerro Pachón, site monitoring continues to be supported by the NOAO South sites group, establishing long-term site characteristics that will be important for planning and successfully carrying out the 10-year LSST survey. Site preparation activity will begin in FY 2010, as preparations are made to “take off the mountain-top” in late 2010, pending funding. As soon as construction funding is available, either from the NSF or additional private sources, activities will ramp up on site with extensive participation from the same groups at NOAO South that supported the construction of both Gemini and SOAR.

As construction of the major facilities on site winds down towards the end of this LRP period, construction of the LSST base facility will ramp up. The current proposal is that the LSST offices will be integrated with NOAO South facilities on the AURA compound in La Serena, providing extensive and quality interaction between the existing NOAO South staff and new arrivals working on LSST. The LSST base facility will also include a significant computing center. Current plans involve building a new computing center, either in the same building or as a separate building, which will support both LSST and all other NOAO South IT needs, replacing the aging computer facility upon which NOAO South currently relies.

Throughout this construction phase, planning for operations also will be ramping up. This will involve not only planning for the operational activities, but also staffing models to carry out those activities. As many NOAO staff on site are now actively
participating in the design and development of the LSST systems, from aspects of telescope control through computing infrastructure, these same staff will most likely provide an excellent core for operational support staffing. Therefore, the development of staffing plans for LSST operations is an integral part of long-term staffing plans for NOAO South in general.

3.3.5 Major planned deliverables: FY 2009–2013
For the coming five years, the major deliverables planned for NOAO South include:

- **FY 2009**: Complete the reconstruction of the Blanco 4-m mirror support system to improve delivered image quality by constraining the movement of the primary mirror. Complete the SOAR instrument support box modifications to support the new series of SOAR instruments, including SAM. Complete and commission SAM in natural guide star mode. Install an instrument maintenance facility in the Blanco Coudé room, including a new clean room. Complete the Wisconsin H-Alpha Mapper (WHAM) installation and begin operations. Install an instrument maintenance facility in the Blanco Coudé room, including a new clean room. Commission the Blanco Extremely Wide-Field Imager (NEWFIRM) at the Blanco 4-m. Complete the Blanco Environmental Control System upgrade, including the primary mirror cooling system. Complete preparations for DECam, including a new f/8 handling station and new filter changing station on the Blanco observing floor. Deploy the first set of new instrument controllers (TORRENT) on selected smaller telescope systems. Complete LCOGTN facilities, including three 1-m telescopes and at least two 0.4-m telescopes, and begin operations. Complete integration of AOSS and begin infrastructure renewal, including major refurbishment of dormitories and dining facilities. Begin pre-construction activities for LSST, including modification of the mountaintop. Complete the third phase of the Cerro Pachón dormitory construction.

- **FY 2010**: Install, commission, and begin science operations of DECam on the Blanco 4-m. Complete the site preparation for LSST construction. Commission the multi-object, wide-field, fiber-fed IR Hydra/ISPI spectrograph. Complete the upgrade of the "planet finder" fiber echelle spectrograph at the 1.5-m telescope, including the TORRENT controller. Deploy the second set of new instrument controllers (TORRENT) on the Blanco Hydra and other remaining Arcon systems. Complete the third phase of the Cerro Pachón dormitory and dining facilities. Complete the design of LSST. Complete the design for renovation of La Serena offices, including LSST office...
and computing facilities. Complete the installation of the fiber connection from both mountaintops to La Serena.

- FY 2013: Commission the new optical spectrograph, OSMOS, for the Blanco 4-m (ReSTAR). Begin construction of the combined NOAO/LSST facilities in La Serena.

### 3.3.6 Potential challenges and opportunities

The major challenges facing NOAO South fall into three major categories: commissioning, staffing, and funding.

The most concrete challenges are the commissioning of the DECam and SAM, but more generally the current plan requires commissioning roughly one major instrument per year along with several minor upgrades per year. Staffing is critical to this commissioning effort as well as the following operations, and we must pursue an aggressive program of staff renewal to replace the roughly 15 senior staff who will retire during this period, while rebalancing the staff skill mix to meet the challenges of the technologies and operational details of the new instruments and telescopes. The integration of the AOSS staff and associated broad support responsibilities, from support for extensive construction to operations, is also a major challenge for this period.

Most of the activities and deliverables above rely upon at least stable and ideally increasing funding in the core NOAO budget as well as significant additional funds from the ReSTAR initiative for the ReSTAR instruments as well as general infrastructure renewal and modernization. Although it is a welcome challenge, managing increased funding is also a significant challenge if it is transitory funding, given that the staff must be found to carry out all of the new and exciting improvements and initiatives that the temporary funding supports.

Great opportunities flow from the new instruments and telescopes that additional funding will enable. If base funding increased at a rate greater than assumed (inflation), much of this increase would go toward more rapid renewal of staff to meet the challenges of supporting the wide variety of new capabilities provided by ReSTAR and related transitory funding. In particular, we must plan to actively support LSST scientific operations as well as the associated follow-up and complementary observation on all of our telescopes. We must integrate the impact of LSST into instrument planning, general operations planning (including telescope scheduling and advance support for time-domain astronomy), and even administrative activities in order to maximize the science produced from LSST.
3.4 Kitt Peak National Observatory

3.4.1 Overview

The Kitt Peak National Observatory (KPNO) continues to be a cornerstone of the US O/IR System. Under an NSF lease with the Tohono O’odham Nation, KPNO maintains the infrastructure on Iolkam Duag (also known as Kitt Peak) that supports 26 telescopes operated by NOAO, the National Solar Observatory (NSO), the National Radio Astronomy Observatory (NRAO), and over 40 universities and university groups.

Over the past 15 years, KPNO has focused its development of new observing capabilities on wide-field imaging and spectroscopy (optical and near-IR) in support of the new generation of large ground-based telescopes (6 to 10 m) and the NASA suite of space-based observatories providing multi-wavelength coverage from gamma-rays to the mid-infrared (e.g., FERMI, GALEX, CXO, HST, and Spitzer Space Telescope). These efforts have included the recent commissioning of the wide-field, near-IR imager NEWFIRM. The culmination of this development of excellent wide-field instrumentation will be realized when the One Degree Imager (ODI) begins routine science operations on the WIYN 3.5-m telescope in 2012. With its state-of-the-art orthogonal transfer arrays, ODI on WIYN will be the leading wide-field optical imager in the Northern Hemisphere.

Like NOAO South, the ReSTAR and 2010 decadal survey reports will guide the next phase of KPNO development. Additional spectroscopic capabilities on 4-m class telescopes are expected to continue as a high priority for NOAO. Among the new initiatives in this LRP period will be the deployment of OSMOS, a medium resolution optical spectrograph, at the Mayall 4-m (see Section 2.3). KPNO will also focus on the completion of on-going modernization efforts and the successful commissioning of ODI (2010–2011). With the continued support of the NSF, this program of modernization and new capabilities will enable KPNO to continue to provide the community with forefront astronomical research opportunities.

Figure 5: Kitt Peak

An aerial view of Kitt Peak, with the WIYN 3.5-m (left, foreground) and Mayall 4-m (background).
As already described for NOAO South, discussions have begun about locating an LCOGTN 2-m class telescope on Kitt Peak (see Section 3.3.1).

### 3.4.2 Major activities

KPNO currently operates three research telescopes while the Kitt Peak Visitor Center (integrated into the KPNO program in January 2009) operates four telescopes used for public outreach and education. KPNO provides the common mountain infrastructure and engineering/technical staff to support the operation of 20 additional non-NOAO, tenant telescopes. These activities are executed through the subdivisions described below.

Unlike NOAO South, KPNO does not handle all of its own administration and facilities services. Rather, it receives support for many of those services from the Administration and Facilities program described later in this document.

#### 3.4.2.1 Director’s Office

KPNO is lead by an NOAO Associate Director, and is managed by a team that includes the heads of the major units. The KPNO Associate Director is the NOAO Administrative Director on the WIYN Board of Directors. The KPNO Associate Director is responsible for normal communications and coordination between NOAO/KPNO and the Tohono O’odham Nation, Pima County, City of Tucson, other surrounding local governments, State of Arizona, Department of Homeland Security Tucson Sector Office, and our tenant observatories. The KPNO Director’s Office also assists the NOAO Director’s Office in reporting and planning activities.

#### 3.4.2.2 Support Office

The KPNO Support Office provides visiting observers for the KPNO, WIYN 3.5-m, WIYN 0.9-m, and NSO Kitt Peak telescopes with pre- and post-observing run logistics support including assistance with travel, dormitory, and meal arrangements. The Support Office also coordinates communication between observers and our technical support staff, ensuring that the desired instrument configurations are prepared for each program. The Support Office collects fees, assists with tracking observatory performance, and prepares information for reports to our oversight committees and funding agency, the NSF. Central Facilities Operations (CFO) based in Tucson (see Section 3.8.2.2) manages the shuttle and bus service used by staff and visiting observers to travel between Tucson and Kitt Peak.

#### 3.4.2.3 Mountain Facilities

The Mountain Facilities group maintains common infrastructure for the mountain (e.g., water plant, phone system, etc.), provides a shared dining facility, responds to safety/emergency calls, and maintains shared buildings. In addition, for the WIYN Observatory, NSO, Kitt Peak Visitor Center, and KPNO, Mountain Facilities maintains the observatory buildings, assists Kitt Peak Engineering with projects and major maintenance, and maintains the mountain vehicles.
3.4.2.4 Mountain Science Operations
Mountain Science Operations includes the scientists and technical support staff that operate the telescopes; change, configure, and support the basic operations of the instruments; orient/teach visiting observers how to use the instruments and telescopes at KPNO and WIYN Observatory; assist in safety/emergency calls; develop the telescope observing and engineering schedules in consultation with the KPNO Director’s Office; and assist the visiting observers in the planning, execution, and post observing data reduction for their science programs.

3.4.2.5 Kitt Peak Engineering
Kitt Peak Engineering (KPENG) is responsible, with the assistance of Mountain Science Operations and Mountain Facilities staffs, for the maintenance and improvement of the telescopes and facility instruments of KPNO and WIYN Observatory. In addition, KPENG helps maintain the McMath-Pierce and Synoptic Optical Long-Term Investigations of the Sun (SOLIS) telescopes of NSO. KPENG also works in collaboration with NOAO System Instrumentation (part of the NOAO System Technology Center described below), WIYN Observatory, and other partners (e.g., various universities and federally-funded laboratories) to construct and deploy new instrumentation on KPNO and WIYN telescopes.

3.4.2.6 Kitt Peak Visitor Center
The Kitt Peak Visitor Center (KPVC) operates a modern visitor center and gift shop visited by tens of thousands of people each year (between 30 and 60 thousand visitors each of the past five years). The KPVC operates four telescopes (three nighttime, one solar) used in a variety of public observing programs during the vast majority of the year, the late summer monsoon season excepted. The activities of the KPVC are currently self-supporting (i.e., not supported by core NOAO funding).

3.4.3 Major planned deliverables: FY 2009–2013
Major planned deliverables in this period include:

- FY 2009: Complete the repair of the Mayall 4-m Dome Rails and fully spare the Dome Trucks. Complete installation of the cooling system required to support the ODI detectors/controllers and the primary mirror cooling system at the WIYN 3.5-m.

- FY 2010: Begin the commissioning of ODI at the WIYN 3.5-m. Deploy two updated controllers (TORRENT) for two existing instruments at the Mayall 4-m.

- FY 2011: ODI begins science operations at the WIYN 3.5-m. Commission the red-sensitive version of the Mosaic-1 wide-field optical imager at the Mayall 4-m. Complete the dining facility and dormitory renovations.

- FY 2012: Commission OSMOS, a high-throughput, (volume-phase holographic, VPH, grism) optical imaging spectrograph to be built by NOAO System Instrumentation in collaboration with The Ohio State University instrumentation group and KPENG (ReSTAR project). Complete renovation and expansion of the Kitt Peak Visitor Center (if funding permits).
• FY 2013: Commission the near-ultraviolet sensitive version of the Mosaic-1 wide-field optical imager at the Mayall 4-m.

3.4.4 Potential challenges and opportunities
The main challenges facing KPNO over the next four years are the following: completing the construction and deployment of ODI on the WIYN 3.5-m; renewing our staff (experienced, but aging, staff requires new hires to be trained as the next generation of engineers, scientists, and technicians supporting the observatory); increasing the number of observatory staff to the size required to support the next generation of astronomical instruments and an increase in the available observing nights; and replacing the revenue for operations and new instruments (approximately $830K per year) previously provided through partnerships with Clemson University and the University of Maryland.

If the base operations budget could be increased at a rate greater than the rate of inflation, the increased funding would be used to increase the size and quality of our technical and engineering staff. This would lead to a more rapid rate of modernization of the existing facilities; better maintenance of the future, modern (and more complex) instruments; and the support of more diverse observing modes, including remote and service observing. In addition to the proposed ReSTAR Phase 1 instruments, a high-resolution, near-IR echelle spectrometer would be of particular interest both for the science it would directly enable and as a pathfinder to building a similar instrument on a future 20- to 30-m class telescope. Such a capability is essential for studies of the astrophysics of planet and star formation.

Finally, the possibility will be explored that further re-organization should occur in Tucson to create an NOAO North unit that more closely resembles the NOAO South unit described earlier.

3.5 NOAO System Science Center

3.5.1 Overview
During this LRP period, the NOAO Gemini Science Center (NGSC) will evolve into the NOAO System Science Center (NSSC) and absorb other existing NOAO activities related to connecting the community-at-large to the present and future science capabilities of the System. This re-organization is intended to streamline access to the System, making navigation within its structure more transparent and thus, more productive, as requested by the NSB and NSF. Such a structure will also allow NOAO staff scientists assigned to NSSC to routinely move between supporting current facilities and engaging the community with new facilities under development.

When fully constituted, the NSSC will provide the following services:
• User support for observing proposal preparation and submission for all of the System facilities as well as post-observing data processing\(^6\)
• Assist non-NOAO facilities as appropriate to improve their interface to the community-at-large (e.g., facility-specific user manuals with a uniform look-and-feel)
• Work with the community-at-large to define and prioritize new capabilities of the System (telescopes, instruments, and data systems)
• Ensure that current and new capabilities of the System are being advertised to the widest possible audience

*In short, the NSSC strives to evolve into a center for end-to-end user support of the System as well as the focal point for developing new operational relationships between NOAO and other science facilities and capabilities within the System.*

At the present time, NGSC, through its interactions with the international Gemini Observatory and the US community, already provides all of the above services for the US Gemini science user community and represents a model on which to develop an expanded science service center. Evolving NGSC into the System-wide NSSC is thus a natural and achievable goal over the next 24 months, depending on funding constraints.

### 3.5.2 Major activities

#### 3.5.2.1 System User Support

The NSSC manages System User Support (SUS) for US community access to the two 8.1-m Gemini telescopes and all other telescopes that provide community access in

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\(^6\) At this time, user support for KPNO and CTIO are assumed to remain the responsibility of those programs. However, a transition of KPNO and CTIO user support into NSSC will be studied over the next year.
return for TSIP funding including the Keck I and II 10-m telescopes, MMT 6.5-m telescope, and Magellan I and II 6.5-m telescopes. Access to the LBT 2 x 8.4-m observatory will begin during this planning period. If ReSTAR funding is received, it should be possible to enable open access time on other 4-m class telescopes (e.g., Palomar Hale 5-m and the Discovery Channel 4.2-m).

NSSC staff scientists provide a number of services in support of community users: preparation of pre-submission technical assessments of any observing proposals being submitted, answers to helpdesk questions from the community, written technical reviews for the NOAO Time Allocation Committee (TAC) on every proposal submitted to NOAO, preparation help to successful principal investigators (PIs) with Phase II submissions to Gemini in order to execute their observing programs, Gemini and other observatory site visits in order to maintain staff proficiency or understanding of the System instruments and operations, maintenance help for the System Web pages covering all open-access capabilities, and participation on Gemini instrument teams in conjunction with Gemini scientists.

In addition, NSSC engages and educates the entire US astronomy community about current issues, new observing capabilities, and science results via the NOAO/NSO Newsletter, the electronic NOAO newsletter Currents, the NSSC Web site, and booths at AAS meetings.

#### 3.5.2.2 System Community Development

NSSC is responsible for system community development, connecting the US community-at-large with new science capabilities under development such as LSST, GMT, TMT, LCOGTN, and various emerging facilities for optical interferometry.

NSSC staff scientists make this connection by:

- Working with the community-at-large to define and prioritize new capabilities of the System (telescopes, instruments, and data systems)
- Active participation in science working groups and advisory committees

Major projects with significant NOAO involvement (e.g., LSST) will have full-time NOAO project scientists leading small NOAO-internal science working groups. Other projects with a lower level of NOAO involvement (e.g., GSMT, LCOGTN) may be assigned project scientists on a part-time basis. These scientists will likely have other responsibilities elsewhere in NSSC or NSTC.

#### 3.5.2.3 Science Data Management

Per NSF request, a mid-term (18–24 month) program plan for Science Data Management (SDM) will be completed by 1 May 2009 and submitted to NSF AST for comment. That plan will include an action plan for the involvement of NSSC/SDM in the Virtual Astronomical Observatory (VAO) project.
Primarily due to current and projected resource limitations, the former Data Products Program was reduced in scope and cost. The new, more restricted SDM program serves specific, immediate, NOAO data management needs. By locating SDM within NSSC, the SDM mission is more strongly connected to end-user science needs and the NOAO scientists who support those needs. As such, SDM activities fall into two broad categories.

SDM Systems Operations (SDM-O) provides the day-to-day services needed to keep the software tools and services deployed by SDM operational. SDM-O is responsible for moving thousands of images each day from all of NOAO’s instruments and telescopes into safe storage; for the continuous ingestion of image metadata into the NOAO Archives; for operating science pipelines to serve NOAO raw and reduced data to PIs; for managing the NOAO Help Desk and interacting with users and instrument teams; and for defining and deploying the hardware needed to support all of these tasks.

SDM Systems Development (SDM-D) focuses on software and other development for projects to meet the immediate and near-term needs of NOAO. Development projects are focused on two NOAO facility instruments: NEWFIRM and DECam. SDM-D may participate in ODI pipeline development if resources permit and such development fits the needs of NOAO and WIYN. SDM-D also maintains core IRAF on various platforms and provides extensions as necessary to be consistent with the NOAO mission (e.g., 64-bit IRAF to support image sizes greater than 2 GB and take advantage of hardware systems with large amounts of physical memory).

As appropriate, SDM will provide user cookbook and operator manuals to support its deliverables.

By the end of FY 2010, SDM envisions that: NOAO PIs will routinely use the NOAO Archives to query and retrieve their raw NOAO data; Mosaic and NEWFIRM PIs will be utilizing pipeline-reduced data products to aid in their scientific analyses; SDM will have the needed infrastructure and documentation to incorporate the raw data flow from DECam into the NOAO Archive; SDM will have the DECam community pipeline integrated into the SDM E2E system and be prepared to operate it; IRAF will continue to be maintained for the most common platforms; and the required support and documentation for these deliverables will be available to NOAO users.

SDM activities beyond FY 2010 are still to be determined and depend on available funding and requirements from primary stakeholders throughout NOAO.
3.5.3 **Major planned deliverables: FY 2009–2013**

Major planned NSSC deliverables in this period include:

- **FY 2009:** Implementation of an NOAO-wide helpdesk. Organize and plan for US community input to the next generation of Gemini instruments, with emphasis on workhorse capabilities that can be implemented on a relatively fast track. Routine ingestion of all raw data from all NOAO facilities into the NOAO data archive. Operation of Mosaic and NEWFIRM pipelines.

- **FY 2010:** Provide technical reviews for all “high value” community observing time: this includes Gemini (already done), Keck, Magellan, MMT, LBT, and any other large-aperture facilities that become available as open-access time. Streamlined Web pages for all community access facilities. Query-capable database of keywords for all archived NOAO (and affiliate) data. A 64-bit implementation of IRAF.

- **FY 2011:** Completed closer linkage of NOAO staff to any non-NOAO facilities that they support, including site visits and training. Routine ingestion of all DECam and DES raw data. Operation of DES pipeline for community data.

- **FY 2012:** Complete planning for future Gemini operations in preparation for the next International Operating Agreement, which will begin in 2013–2014.

- **FY 2013:** NSSC steady state, with built-in staff flexibility to handle any changes or evolution in System operational capabilities.

3.5.4 **Potential challenges and opportunities**

The major challenges facing NSSC over the next four years are potentially difficult, but exciting, as they involve increasing amounts of observing time on both existing and new major facilities.

On the System User Support (SUS) front, one crucial task will be mustering the staff expertise on-hand to support increased access to 6- to 10-m facilities as recommended by the ALTAIR committee, at both Gemini and non-federal facilities.

A “bump up” in TSIP will involve both new instruments and increased access to current facilities (such as Keck, Magellan, MMT, or LBT) as such opportunities arise. More TSIP time and an increased share of Gemini will require both a greater amount of and increasingly diverse support from NSSC staff. Another requirement on NSSC will be to improve the ease with which users can interface with an evolving and increasingly capable US System. Such an integrated and navigable US System will treat both Gemini and TSIP access on a par with each other. NSSC must also remain
involved in helping the US community-at-large define requirements for the next set of Gemini instruments.

While System Data Management (SDM) must remain focused on near-term projects, such as archives and pipelines required for Mosaic, NEWFIRM, and DECam, it will be challenged by pressure to participate in ODI, as well as VAO. SDM must balance resources and priorities for future commitments. Within the newly restructured NSSC, SUS will find it necessary to foster stronger ties to SDM in order to tap some of the skills within SDM, which will represent another challenge. One SUS task that will naturally drive these new links will be more uniform user support for all of the non-NOAO facilities; such support will include data collection and reduction for a broad range of instruments and capabilities. Data handling skills within SDM will be an asset in supporting user access to non-NOAO facilities.

During the time frame of this LRP, System Community Development (SCD) will be faced with the challenge of engaging the US community in the impressive set of science capabilities that will be enabled by the major new facilities that are under development, namely LSST and the two US-led ELT projects, GMT and TMT. It remains important for SCD to keep LSST as a “high profile” project and to maintain US community interest as LSST moves towards Preliminary Design Review. In advocating for community interests in both GMT and TMT, the SCD group must represent itself as the steward of US open-access to these facilities, engage equally with both projects, and work with the community to help define requisite science capabilities.

Meeting the challenges discussed above will lead the US user community into a regime of new scientific opportunities that will be provided by a truly integrated, diverse, and robust US System of ground-based telescopes and capabilities. These more integrated capabilities will be of enormous benefit to the next major facilities, LSST and GSMT, by providing combinations of spectroscopic follow-up, along with aperture and field-of-view balance to use in conjunction with the unique potential of LSST and GSMT.

### 3.6 NOAO System Technology Center

#### 3.6.1 Overview

The NOAO System Technology Center (NSTC) is responsible for coordinating technological enhancements to the System. As such, it takes the leadership role on the technical activities within NOAO needed to realize new telescope projects or to enhance the instrument complements on existing US System telescopes operated by NOAO or other entities.

The NSTC incorporates three programs serving these goals: (1) the System Instrumentation program, which oversees the direct efforts of NOAO to build new instruments for its own telescopes, for the Gemini telescopes, and for other telescopes participating in the System; (2) the LSST program, which provides scientific, engi-
neering and management support to the LSST Project and is responsible for telescope mount, enclosure design, and site work within the LSST partnership; and (3) the Telescope System Instrumentation Program (TSIP), which provides funding to other observatories for new instrumentation in return for time on their telescopes being made available to the US community through the NOAO TAC. TSIP is funded by NSF outside the NOAO base budget.

The following paragraphs assume that NOAO is awarded supplemental funding to implement Phase I of the recommendations of the ReSTAR implementation report near the end of FY 2009.

### 3.6.2 Major activities

#### 3.6.2.1 System Instrumentation

The System Instrumentation (SI) program will execute several projects during the planning period. Some of these projects are funded completely from NOAO base funds (e.g., SAM, MONSOON/TORRENT). Others are enabled by base funding, via engineering and technical support for example, but require supplementary funds for construction (e.g., the ReSTAR instruments).

**NOAO instrumentation**

SI will complete the SOAR Adaptive-Optics Module (SAM) currently under construction at NOAO South. This laser-guide-star-equipped, ground-layer adaptive optics system is planned for commissioning in two phases: the main adaptive optics bench will be commissioned in limited, natural guide star mode starting around the end of FY 2009; and the laser guide star system will be commissioned about one year later. When completed, this system will make possible image quality enhancements that can turn 0.8-arcsecond FWHM natural seeing into ~0.3-arcsecond corrected images, with uniform image quality over fields of view of a few arcminutes, at observing wavelengths across the visible light spectrum (through $B$ band), and over most of the sky.
SI will also complete the re-engineering of the MONSOON detector controller into a smaller, more energy efficient package, nicknamed TORRENT, that is suitable for a low-cost replacement of aging detector control systems now in use at CTIO and KPNO. The re-engineering and re-packaging will lead to a production-ready prototype by the end of FY 2009. During FY 2010, the MONSOON group within SI will build and test production units and assist the CTIO and KPNO engineering staffs with integrating them into existing instruments. This program will result in improved reliability of the observing systems, greater efficiency through faster readout speeds and reduced downtime, easier maintenance by mountain personnel, and, in some cases, reduced electronic noise in the CCD images.

**ReSTAR Instrumentation**

If the supplemental funding for the ReSTAR program implementation is awarded late in FY 2009 as hoped, SI will begin the program of constructing new instruments for NOAO and US System 4-m telescopes as outlined in the ReSTAR implementation proposal. These new instruments will be largely completed by the end of this planning period.

The first instrument will be a near-clone of the OSMOS spectrograph, to provide a modern, efficient spectroscopic capability on the KPNO Mayall telescope. This OSMOS copy will be built in close partnership with the group at The Ohio State University that is currently building the original OSMOS for a 2.4-m telescope. The program is projected to take about 18 months, leading to delivery of the OSMOS copy to KPNO during FY 2011.

The second ReSTAR instrument program will be a near-copy of the successful TripleSpec near-infrared spectrograph. NOAO will carry out this construction program in close partnership with the group at Cornell University that built the original Tri-
pleSpec for the Hale 5-m telescope at Palomar Observatory. This program will require a modest amount of time to study the impact of certain design changes to make TripleSpec more closely match the science goals of the ReSTAR committee report; hence, this project will require a little more time before the launch of actual construction. This project is expected to require about 24 to 30 months after a start in early FY 2010, leading to a delivery to the CTIO Blanco telescope sometime late in FY 2012.

Studies for design options of the third instrument under the ReSTAR program, a high-resolution optical spectrograph, will be launched in FY 2010. Nominally, this instrument is targeted for the Lowell Observatory Discovery Channel Telescope (DCT). As this instrument will be an original design (not a near-copy of another), it is expected to take longer; completion will probably not occur until FY 2013.

**Figure 9: OSMOS**

Drawing of Ohio State MultiObject Spectrograph (OSMOS).

**Figure 10: TripleSpec**

One copy of TripleSpec, on the floor of the Apache Point 3.5-m telescope. Another copy has been deployed at the Palomar Hale 5-m, while a third copy is destined for the Keck 10-m.
Finally, if the ReSTAR implementation proposal receives sufficient funding or NOAO base funding becomes available, SI could build one additional copy each of OSMOS and TripleSpec, so that the Mayall and Blanco telescopes can be equipped with both instruments. In each case, the second copy of the instrument is expected to cost about 25% less than the first copy thanks to savings on non-recurring engineering and design costs, and to time savings during integration and testing. Both potential university partners have indicated interest in exploring the possibility of making two copies in rapid succession, which is the planning model under which the greatest cost savings can be realized.

3.6.2.2 Telescope System Instrumentation Program
The Telescope System Instrumentation Program (TSIP) is funded by NSF outside of the normal NOAO base budget and administered by NOAO. Through this program, NOAO selects instrument projects or telescope operations funding proposals at non-federally funded observatories to receive NSF funding, and in return these observatories provide observing time to the US astronomical community through the NOAO TAC in proportion to the amount of TSIP funds awarded. For each year in which NSF makes the supplemental funding available for TSIP, NOAO will issue a call for proposals, convene an independent review committee to evaluate the proposals, and select proposals for funding based on the committee’s recommendations (final approval for each award is made by NSF). NOAO will then monitor the performance of the funded project, to ensure that the NSF funding is being spent wisely, and track the scientific success of and user satisfaction with the telescope time provided.

The ALTAIR committee is recommending an expanded TSIP program to gain more open access on large aperture telescopes. If funding does materialize to expand TSIP, there will be a need to plan more strategically. The TSIP program may thus evolve to include calls for proposals that specifically seek to balance capabilities across all of the System telescopes. This balance would include the Gemini telescopes as well as any future international access points. By the end of the planning period, TSIP may also evolve to include instrument development for ELTs with telescope time coming from ELT partners’ existing 6-m to 10-m allocations.

3.6.2.3 NOAO LSST Program
The LSST Project will be carried out by the LSST Corporation (LSSTC), which was established as a non-profit 501(c)3 corporation in the state of Arizona by NOAO, the Research Corporation, the University of Arizona, and the University of Washington. Membership in the project has grown to 27 institutions, including universities, Department of Energy (DOE) laboratories, and private organizations. LSSTC submitted a construction proposal to the NSF Major Research Equipment and Facility Construction (MREFC) program in February 2007 requesting $241.6M toward the project cost. The NOAO LRP assumes that the LSST will be an MREFC new start in FY 2012.
NOAO has provided continuous support to the LSST Project since its inception, beginning with a joint presentation with the University of Arizona to the O/IR panel of the 2000 Astronomy and Astrophysics Decadal Survey. Starting with early development of the scientific case and working with partners to establish design concepts, NOAO has provided critical scientific, technical, and programmatic support to the project. NOAO will continue to provide this support as LSST completes the design and development effort and prepares for construction authorization.

The primary role of NOAO in LSST technical development is in the telescope subsystem development. This includes the full articulating telescope structure, optics, summit facility, dome, control system, and support facilities like the coating chamber and photometric monitoring telescope. It also includes the sea-level base facility in La Serena that supports the operations team and the data management computer system for nightly processing as well as the servers and storage needed to be an LSST Data Access Center. NOAO also provides unique support to the development of the observatory control system, the operations simulation code, and the survey scheduler.

NOAO plays a lead role in establishing the current corporate and project structure and is active in the governance of the project, which is the responsibility of the LSST Board. NOAO scientific staff members are active in defining the science requirements for the project and engaging community participation. NOAO has collaborated with the LSST Project and the DOE lab at Stanford to solicit community participation in the LSST science collaborations. These collaborations are teams of professionals; each is focused on one of the high-priority science missions of the LSST. Science teams are charged with determining the requirements for carrying out each mission, planning precursor observations, simulating performance, providing feedback to the LSSTC through the Science Advisory Council, developing special-
ized software tools and pipelines that may be required, and organizing the core analysis to be performed with LSST computational facilities. The TAC-like process to review proposals recently succeeded in bringing over 60 additional US scientists into the 10 science-based collaborations.

Funding to support the LSST efforts at NOAO stem from the base budget and are supplemented (SPO 1) with funds from the NSF four-year grant specifically for LSST Design and Development. The LRP continues the base support for the NOAO LSST Program in FY 2009–2011. The focus of the effort in this period is preparation for the preliminary design review expected in mid to late FY 2009 and then the final design review in FY 2011. The team will continue to develop the design to the goal of improving the level of prototype testing and detailed design necessary for the planned, smooth and efficient start to construction. We assume the LSST Project will work separately with the NSF to continue providing supplemental funding with the Design and Development Grant.

In FY 2012 and FY 2013, the NOAO LRP shifts focus. All engineers working directly on LSST will be supported by LSST MREFC funding. Scientific staff members are not included in the MREFC budget, and NOAO will continue to support those scientists as they focus on preparing the US community for the era of LSST astronomy and preparing the organization to support LSST operations.

The major LSST milestones for the LRP period of FY 2009–2013, assuming steady supplemental funding to augment the base funding, are:

- FY 2009: A completed preliminary design of the Telescope and Site system including a fully revised and updated cost estimate and construction schedule. In parallel, and in the following years, continue to build NOAO science staff participation in LSST science and operations planning.
- FY 2010: Completion of an LSST Operations Plan. The LSST will be sited on Cerro Pachón in Chile where NOAO/CTIO is well positioned to provide operations support. NOAO will work with LSSTC to establish an efficient operations model and will work with AURA, NSF, and the LSST Project to develop operations proposals that are consistent with LSST requirements and also optimize the use of the total NSF investment on Cerro Pachón and at CTIO.
- FY 2011: A completed final design review of the Telescope and Site system. This will also include the completion of several contracted design phases scheduled to allow smooth transition of several design/build contracts to construction. The critical path for the LSST runs through several Telescope and Site activities and the risk of these activities will be mitigated through preparations made for rapid contract starts upon MREFC authorization.
3.6.2.4 GSMT/ELT technology
Although not a formal partner in any GSMT/ELT project, NOAO continues to provide engineering assistance to the GMT and TMT projects upon request and on a cost-recovery basis.

3.6.3 Special topic: development of instrumentalists

3.6.3.1 ReSTAR sub-program: instrumentation internships
As instruments for ground-based telescopes become bigger, more expensive, and more time-consuming to build, it becomes harder for young scientists interested in instrument development to get significant experience with a project during the limited span of a graduate program or post-doctoral fellow appointment. NOAO will make a specific effort to address this issue through its implementation of the ReSTAR committee recommendations.

Each of the new instruments built under the ReSTAR program will be built through a partnership with a university instrumentation group. The partnerships will explicitly include at least one graduate student fellowship for each project. These fellowships will be funded in part from project funds and in part from a contribution from AURA made out of its management fee.

The fellowships will be structured so that each student will have time to work on both instrument construction/commissioning and science verification. The students will thus experience both building a new instrument and using it for scientific observations.

Should additional funding beyond ReSTAR become available for new instruments, NOAO will ensure that each subsequent project includes well-directed efforts to engage junior instrumentalists at every stage.

3.6.3.2 Technology post-docs
NOAO has committed to funding one to two post-doctoral fellows for astronomical technology development, starting in FY 2012. These post-docs will be encouraged to work at either Tucson or La Serena on any of the broad range of telescope, instrument, or data management projects supported by NSTC. Activities related to LSST or GSMT will be especially encouraged.

3.6.4 Major planned deliverables: FY 2009–2013
Major planned deliverables in this period include:

- FY 2009: SAM Main Module begins commissioning at SOAR telescope. TORRENT controller achieves production readiness.
- FY 2010: OSMOS copy construction partnership is launched. TripleSpec copy construction partnership is launched. SAM Laser Guide Star begins commissioning at SOAR telescope. TORRENT controllers are integrated into existing instruments at CTIO and KPNO.
• FY 2011: ReSTAR high-resolution spectrograph construction partnership is launched. OSMOS copy begins commissioning at the Mayall telescope.
• FY 2012: TripleSpec copy begins commissioning at the Blanco telescope.
• FY 2013: ReSTAR high-resolution spectrograph begins commissioning at the DCT.

3.6.5 Potential challenges and opportunities
The greatest challenge facing the NSTC is the ability to attract and retain the talented people needed to carry out the programs above. Currently, most of the NSTC engineering staff work with the LSST Project Office; the LSST effort is expected to remain essentially constant until MREFC funding is received, and then to increase dramatically. The ReSTAR instrument developments are also expected to require engineering talent, and it will probably be necessary to hire from one to three additional engineers using the supplemental ReSTAR funding. When LSST receives its MREFC funding, additional staff will be needed there as well.

If funding were to be found to support additional work within NSTC, there are many other ways that NSTC could contribute to the System. The ALTAIR committee reported on substantial community dissatisfaction with the instrument complement at Gemini. Supplemental funding could allow NSTC to build a modern, efficient, workhorse spectrograph for Gemini, the System’s flagship facility.

The ReSTAR report provides other examples. The Phase I implementation proposal provides for only a few of the most urgent recommendations. Further supplemental funding beyond the Phase I proposal could allow NSTC to implement a community-based, time-domain observing capability by providing the resources for NOAO to be a full partner in LCOGTN. Of course, any such additional funding would add to the challenge of finding sufficient technically skilled people to carry out the work, as described above.

3.7 Office of Science

During FY 2009, the roles, responsibilities, and goals of the Office of Science (OS) are being defined, and an organizational structure is being implemented to enable the program’s success.

The OS is a new umbrella for (mostly) existing activities related to the scientific staff activities at NOAO (promotion and tenure, research support, community development). The OS Head of Program reports to the NOAO Director.

3.7.1 Overview
On behalf of NOAO and community scientists, the OS Head of Program will be a representative to the NOAO Director for enhancing scientific productivity by:
• Providing support for research activities of NOAO scientists including fund-
ing, NOAO telescope time, and mentoring (especially for post-docs and early-
career scientists)
• Establishing stronger ties to community scientists
• Improving the visibility of the scientific accomplishments at NOAO by NOAO
scientists and community scientists using NOAO facilities
• Facilitating timely resolution and improving transparency of the hiring, pro-
motion, and tenure processes

The OS Head of Program is also responsible for ensuring the successful operation of
the NOAO time allocation process.

There exist several models in the community for an OS, such as the NRAO Office of
Science and Academic Affairs, and the European Southern Observatory Directorate
of Science, that offer encouraging evidence that these goals can be achieved.

3.7.2 Major activities
During the transition period following the 2006 Senior Review, career development
actions for the scientific staff were slowed significantly as the NOAO mission was re-
cast. Activity is now greatly increased in the following areas:
• Promotion reviews for scientists and tenure-track scientists
• Fourth year (pre-tenure) reviews for tenure-track scientists
• Post-tenure reviews
• Research budget re-allocations across all of NOAO to improve the uniformity
of research opportunities across all divisions
• Meetings with each scientist by the Head of Program in order to enhance
each individual’s science potential, to understand their challenges, and to
identify those who need additional career development
• Analysis of the scientific productivity across the entire staff, to better under-
stand the competitive status of NOAO scientists, to identify individuals who
excel, and any individuals who may be better suited to an alternative track
• Re-energize the mentoring program across NOAO, to identify and train senior
scientists to serve as mentors, and to match early-career scientists with these
volunteers
• Clarify (and revise as needed) the processes guiding promotion, tenure, and
post-tenure reviews

In addition, the OS has assumed responsibility for the NOAO/NSO Newsletter Science
Highlights section.
3.7.3 NOAO Time Allocation Committee

The NOAO Time Allocation Committee (TAC) is charged with the scientific assessment and ranking of observing proposals for all NOAO-coordinated facilities (KNO, CTIO, Gemini, and TSIP allocations). The NOAO TAC meets every six months, approximately one month after each proposal submission deadline. Fundamentally, the TAC is advisory to the NOAO Director.

The OS Head of Program is responsible for the efficient, open, and fair operation of the TAC.

3.7.4 Major planned deliverables: FY 2009–2013

Major planned deliverables in this period include:

- FY 2009: Over a dozen promotion and tenure committee recommendations to the Director; an analysis of the scientific productivity and demographics of the staff; newsletter contributions (four issues); prepare a report to the Director summarizing ~60 scientific staff interviews and recommendations for improving staff research performance; Web pages summarizing guidelines for promotion and tenure, and opportunities for research funding within NOAO
- FY 2010: Continue promotion, tenure, post-tenure reviews and recommendations; newsletter contributions; reinstatement of mentoring program; begin implementation of recommendations on staff research productivity
- FY 2011–2013: Steady-state, see FY 2010

3.7.5 Potential challenges and opportunities

Although the NOAO science staff is highly productive, their research potential is limited in several ways. Chief among these are funding for data aides, students, post-docs, and general purchases (travel to conferences and observing runs, computers, special equipment such as filters). In addition, graduate student participation in NOAO staff research is minimal, in part because NOAO is not a degree granting institution. Several NOAO staff have circumvented the lack of funds and the ban on applying for NSF research funds by obtaining NASA funding; while this strategy can be effective scientifically, it can detract from the mission of NOAO if scientists divert too much of their attention to NASA facilities instead of those at NOAO (some programs are an effective mix of ground and space-based observing).

With an average age in the 50s, the scientific staff is a relatively senior group. Long-term budget pressure at NOAO has made it impossible to hire junior scientists to replace retiring and departing staff members. If this situation continues, enormous corporate knowledge at NOAO and its technical and scientific leadership will be lost in the next 5–10 years. The problem is exacerbated in Chile where hiring into a foreign culture is more difficult, especially when trying to broaden diversity.
In recent years, several oversight committees have asked NOAO to consider the implementation of observing schools or workshops. The NOAO staff includes experts that can serve as teachers in a “school” or “workshop” environment to benefit the astronomical community (advanced graduate students, post-docs, some faculty). These schools could be held annually for groups of 15–25 (depending on the subject matter and space availability), for periods of about one week. To improve access to the community, the course material would be made available online, and perhaps also made available in video format via DVD. The latter will add cost to the program, but might make it more attractive to the general community. Currently, NOAO does not have the funding or staff time to further develop and implement this concept; but it may be possible to find funding in the future.

Many of the concerns raised in this section could be corrected with additional funding. For example, NOAO could be running graduate student and post-doc programs like those at NRAO, thereby serving to enhance the scientific atmosphere and to train early career scientists in the techniques of data taking, reduction, and analysis, as well as developing instrumentation—all areas where the field of astronomy is becoming weaker. In addition, NOAO desperately needs additional scientific staff (especially at NOAO South) to lead developments for new facilities coming online (e.g., commissioning new instruments for SOAR, adapting DECam tools for the NOAO community, preparing the observatory and the community for LSST).

3.8 Administration and Facilities

The initial integration of AOSS back into NOAO should be completed by the start of FY 2010. After that, it is likely this section will be revised.

3.8.1 Overview

The overall mission of Administration and Facilities is to provide cost-effective, modern, and timely administrative services and facilities for NOAO and affiliated institutions and observatories, including: the National Solar Observatory (NSO), WIYN Consortium, SOAR Consortium, LSST Corporation, SMARTS Consortium and AURA Corporate.

During the next five years, the focus will be on refining policies and procedures to meet the new NOAO strategic structure and technologies. This includes:

- Improving data information management reporting and access
- Process standardization (especially between Tucson and La Serena)
- Upgrading Web-access software
- Meeting compliance requirements
- Maintenance and repair of facilities
Focusing on these areas will provide efficiencies in support, improved working atmosphere and conditions, and timeliness of responses.

New regulatory policy and procedures will demand compliance in all areas of administrative, facility, and computer information support systems. Code compliance, especially in the area of life safety codes, needs our immediate attention. Expanding fire sprinkler systems, increasing fire detection systems, monitoring fresh air or CO₂ monitoring within HVAC systems, and electrical improvements are at the top of our priorities. Many of the primary building systems were installed under guidelines or national building codes that were applicable at that time but are not compatible with new and updated codes. Other examples include new electrical codes that require a duplex receptacle on every wall of an office. NOAO has some offices with only one outlet. Our old electrical panels and switchgear still are operable but due to their age, parts and support are no longer available.

3.8.2 Major activities

3.8.2.1 Central Administrative Services

Central Administrative Services (CAS) is the hub of the business administration system. Ensuring compliance with various NSF and federal regulations, standardization of policies and procedures across NOAO, and general data collection and reporting are the main foci of CAS activity. These areas include, but are not limited to:

- General accounting, payroll, and audits
- Budget and management
- Compliance, reporting, and regulatory oversight
- NSF proposal and report submission and monitoring
- Human resources and employee relations
- Sponsored projects
- Procurement
- Purchasing, shipping/receiving, and export control
- Business IT

Development, communication/training, and oversight of the administrative processes and compliance are the responsibility of CAS. Administrative oversight of the AURA cooperative agreement with NSF guides the operations and reporting along with various federal, state, and local regulations. CAS acts as an extension of AURA Corporate and provides access to the NOAO cooperative agreement administrative operations—ensuring compliance and reporting. Many of the policies and procedures are developed in conjunction with AURA and/or implemented through CAS. The CAS Human Resources (HR) Office also oversees expatriate administration including visas, recruitment, benefits, and other support in Chile where appropriate.
In addition, full business administrative support is given to the affiliate organizations and AURA Centers through several business service agreements.

For NOAO South, CAS provides all the general services for CTIO Operations through the CTIO Director, for expatriates, and for programs with the exception of those required to be managed by AURA-O. These include accounting, audit, compliance, contracts, human resources, exporting, relocating of staff, budgeting, shipping, and receiving.

AURA-O is the legal entity recognized by the Chilean government. AURA-O oversees and administers Chilean payroll and has labor-specific oversight, especially in connection with labor union agreements, local purchasing, the La Serena Recinto (compound) facilities, and mountain operations. In FY 2010, this operation will be formally re-instated under CTIO, however, AURA-O will continue to have oversight where required. CTIO will incorporate the AOSS portion of the operation. CAS will work to fully integrate systems and reporting with CTIO, but compliance, accounting, and official reporting for all of NOAO will remain in Tucson. NOAO South will account for, oversee, and implement operational needs wherever possible.

Over the next five years, CAS will need to modernize and upgrade procedures and systems to meet the demands due to increased regulations and plans to meet the new cooperative agreement provisions. This will be accomplished in part by the institution of a new Web-based budget system, a new AURA-wide Web-based human resources and payroll system, expansion of the current requisition system (Reqless), and document storage systems. This will be especially important as CTIO re-integrates the observatory services support operations formally known as AOSS. Utilizing new developments and technology to effectively improve its services, CAS will be able to provide not only basic administrative support but also form an umbrella of compliance and remain current on best practices, compliance requirements, and administrative developments affecting the organization and the NOAO community.

The Sponsored Projects Office, which provides pre- and post-award support of our grants and sub-awards, will need to have the flexibility to respond as programmatic needs change. During FY 2009–2011, support to the stimulus funding contracts, ReSTAR implementation, and developing expertise in electronic submission and reporting will be in the forefront. In the following years of FY 2012 and FY 2013, support to programs such as LSST and ATST and NOAO South projects will be needed.

As noted above, CAS provides expertise and leadership to our affiliates and AURA Centers, but it especially acts as the point of contact and support for insurance, export/import and shipping/receiving to Chile, as well as for legal, audit, and general compliance. Some of this support extends throughout the astronomical community due to the special status of AURA-O and export regulations. The challenge for CAS
during the LRP period is to find the right balance of support within budgeting and staffing constraints or expansion. Currently CAS is able to provide a wide range of efficient and inexpensive services through economies of scale and the systems developed. The addition of new projects and facilities at NOAO South will pose challenges to develop policies, procedures, and systems that are cross-cultural as well as standardized for all NOAO employees and affiliates.

3.8.2.2 Central Facilities Services
Central Facilities Operations (CFO) has oversight for the main buildings and facility support operations in Tucson. These operations include:

- General building maintenance support
- Shuttle and vehicle operations
- Building renovations
- Janitorial and security services
- Parking
- Property management
- Facilities compliance reporting

In conjunction, CFO shares some staff time with KPNO mountain operations.

In Tucson, the main buildings house several programs including NOAO. The nighttime astronomy community includes NOAO headquarters, WIYN, the LSST Project, and leased space to the Large Binocular Telescope for actuator development and to the TMT program. The solar community includes the National Solar Observatory headquarters, GONG, SOLIS, and ATST. These facilities are overcrowded and need major upgrades and repairs that will be difficult or impossible for NOAO to handle within projected base budget allocations. Over the last 10 years, CFO has worked diligently to reduce utility and operational costs, including major projects in the area of roof repairs, HVAC, electrical, and water main upgrades. Re-engineering of space is constantly undertaken to meet the needs of the programs.

In FY 2009, CFO has delayed important basic maintenance decisions to modernize and repair our aging facility. If stimulus funding is provided, CFO will focus on upgrades to the Tucson facilities and, where possible, support the KPNO modernization.

Some areas of focus for stimulus work packages are:

- Focused upgrades to meet current building codes (e.g., fire detection systems)
- Energy savings and conservation
• Repairs and renovation, including re-engineering of space to meet new functions and usage per the LRP program needs
• Code compliance, including meeting the new federal regulations and Executive Orders for government facilities

Most of the possible stimulus support will be actualized through contracts to outside vendors/contractors. Until the funding is realized, CFO will continue to be creative in our operations and make efficiencies and repairs wherever possible.

While the primary core function of CFO is to provide facilities support to NOAO North and South, support also is given to NSO, SOAR, and WIYN. Funding for support is provided through a recharge indirect rate revenue process. CFO also receives revenue from Gemini for support of their computer security access system.

At NOAO South, CFO provides the interface and administrative support for the phone and VoIP system. Expanding this system to include voice mail and other automated systems will be the focus at NOAO South over the next several years. CFO North will continue to provide necessary support wherever possible.

Beginning in FY 2009, CFO will develop a new comprehensive plan to further implement over the next five years renovation and efficiency changes in light of new compliance issues with the Energy Policy Act and recent Executive Orders for federal facilities.

3.8.2.3 Computer Infrastructure Services

Computer Infrastructure Services (CIS) in Tucson installs, maintains, supports, upgrades, and secures the computers and networks within the NOAO North downtown facility with the exception of general business IT support.

On Kitt Peak, CIS supports the network infrastructure; computer support is the responsibility of the individual NOAO and NSO units and of other institutions. While the primary core function of CIS is to provide computer infrastructure support to Tucson headquarters, support also is given to NSO, LSSTC and WIYN. Revenue is generated through indirect support to areas other than NOAO and NSO. NSO directly transfers funds to CIS to provide support.

CIS cooperates closely with its counterpart organization at NOAO South to maintain common standards and procedures. In addition, the two organizations maintain the technology that ties the two halves of NOAO together: email, VoIP telephones, and video conferencing. Finally, both IT support groups cooperate in the creation and maintenance of cyber security policies and procedures that are in compliance with those incorporated into the cooperative agreement.
Upgrading of systems, computer labs, and network connections are of utmost priority. Bandwidth and data storage will need to expand due to increased usage by, not only NOAO, but also by LSST, ATST, and other users.

Over the next five years, integration and cooperation between NOAO North and NOAO South will need to be reviewed. While location and distance still may require some duplication of efforts and separation of duties and oversight, the need to standardize policies, procedures, software, and hardware will provide economies of scale, expertise, and transition training. Compliance and efficiencies will be a focus. Developing a more comprehensive cyber security plan will have priority. Restructuring the North and South CIS to include a coordinator to provide vision, continuity, compliance, and procedural guidance will be the key to keeping the two operations in sync.

3.8.3 Major planned deliverables: FY 2009–2013

Major planned deliverables in this period include:

- FY 2009: Provide guidance and support to implement stimulus contracts, integration of AOSS, assist in the modernization and upgrading of NOAO North and South facilities and computer labs. Develop and implement the Broader Participation Data Collection process and programs for STEM recruitment, training, and retention processes. Work to develop more proactive data management systems, including preparing data for transition to the HR system, Web-based budgeting, and facilities work-order systems.

- FY 2010: Train for and implement compliance on the new cooperative agreement, implement new Web-based software, and review all financial systems in conjunction with AURA for consolidation of use. Recommend a software plan for the next 5–10 years of operational needs. Continue major upgrades and stimulus contract work including improving the cooling and power in the Tucson computer lab to provide for maintainability and for expansion to increase the network bandwidth from Kitt Peak to Tucson to speeds approaching 1 Gbps. Develop a plan to restructure CFO to mirror NOAO South operations, removing compliance and other administrative needs to CAS.

- FY 2011: Finalize the transition of AOSS to CTIO. And begin to transition the administrative process from facilities to CAS as CFO transitions operations to KPNO. Continue to improve the maintainability of the Tucson facility network by improving redundancy and by procuring spare parts.

- FY 2012: Install and transition to new financial and reporting software. Undergo the NSF Business Service Review, assist the NSF committee, and respond to the AURA Management Review. Begin a project to install generator back-up power to portions of the Tucson computer lab and the PBX room.
• FY 2013: Prepare a new cooperative agreement proposal and submission. In cooperation with the University of Arizona, increase the bandwidth from NOAO-Tucson to the scientific Internet from 1 Gbps to 10 Gbps.

3.8.4 Potential challenges and opportunities

Administration and Facilities challenges and opportunities first and foremost depend on funding. Currently, we have several single points of failure including staffing support, hardware and software challenges, and maintenance and repairs costs. Many of our system upgrades, staffing needs, and modernization of programs have not been fully implemented due to flat funding. While we have the expertise to handle most functions, we do not have the levels of staffing to cover vacations, long-term absences, or provide timely response. In some areas we have reduced staff to meet budget constraints through interfaces for software, hardware, and facilities programs that are now not supported by their vendors. This is especially noticeable in the IT support areas of Business IT, Facilities IT, and general software support.

Furthermore, the aging physical infrastructure in Tucson is hindering the ability to maintain and/or upgrade the facilities. Meeting codes and maintaining compliance is almost impossible to do without major rebuilds. The cost is becoming prohibitive. A new facility should be considered as the more cost effective and prudent choice in the long run.

In CIS, the capacity (space, power, and cooling) of our computer labs needs to be increased to meet scientific needs for data storage, reduction, and access for new generations of telescope instrumentation. Procuring additional space suitable for disks and servers would be very expensive. Likewise, we need to make sure that network bandwidth, both from Tucson to Kitt Peak and Tucson to our "customer" universities is sufficient to support the new instruments that will be coming online.

Administrative and facilities staff members are constantly challenged to meet timelines, balancing the priorities as best as possible. Furthermore, due to our aging staff demographics, we need to develop transitional expertise in a timely manner. This is the opportune time to review our own NOAO program needs in conjunction with our affiliate and community support. The stimulus package will provide for some modernization and support, however, NSF should consider whether providing a brand new facility would be a better opportunity to find efficiencies and cost savings in the long run.

3.9 Education and Public Outreach

3.9.1 Overview

The main deliverables of Education and Public Outreach (EPO) are:

• Educational outreach in Arizona and Región de Coquimbo in Chile (and beyond as funding permits)
• Dark sky preservation near NOAO observatory sites (and beyond as funding permits)
• Engagement with the US professional astronomical research community
• Media relations

Related secondary deliverables include:
• Develop and maintain the central NOAO Web presence
• Develop and orchestrate the NOAO booths at AAS meetings
• Manage the creation and delivery of the quarterly *NOAO/NSO Newsletter*
• Support *Currents*, the NOAO e-newsletter

3.9.2 Major activities
NOAO maintains an active and nationally well-respected EPO group with primary responsibilities as described in the bullets above. These EPO deliverables include an active education program that serves, in the long term, to protect the dark skies at our observatory sites. These core activities also emphasize the importance of the public outreach mission of NOAO in communicating with the public and with the research community. NOAO maintains a vigorous outreach effort in Arizona and Región de Coquimbo through a portfolio of programs that serve students directly and that provide professional development for teachers. In Chile, a major effort is being made to train astronomy guides for public observatories. NOAO North and South work closely together on education efforts using videoconferencing to link the EPO professionals from both sites and to connect students and student programs in Tucson and La Serena.

Key Programs include:
• Project ASTRO—A teacher-scientist partnership program for the Tucson region
• Astronomy Research Based Science Education—a teacher research program currently in a re-planning phase
• CADIAS—an outreach center near La Serena providing important primary school programs and public programs
• Tohono O’odham education efforts—this includes work with the schools, the college, and informal venues of the Tohono O’odham Nation
• Hands-On Optics—a variety of efforts from the national program that are conducted in the Tucson area

Other NOAO projects of importance are:
• International Year of Astronomy Dark Skies Education (C. Walker at NOAO leads both the national and international working groups) and GLOBE at
Night, a key, regional and international program. All of these efforts mesh with dark sky education efforts in Arizona and Chile.

- Galileoscope (S. Pompea leads the national working group doing most of the development work and co-leads the international team).

When the Public Affairs and Educational Outreach program was restructured as EPO with Stephen Pompea as head, NOAO had a number of contractual grant responsibilities, many of which are congruent with the deliverables above. These four programs that are ending this fiscal year or shortly thereafter include:

- Hands-On Optics Arizona (funded by Science Foundation Arizona)
- Building Information Technology Skills through Astronomy (funded by Science Foundation Arizona)
- Astronomy from the Ground Up (funded by NSF ISE with partners Astronomical Society of the Pacific and the Association of Science Technology Centers)
- International Year of Astronomy 2009 (funded by NSF AST with partner American Astronomical Society)

The several projects in their final stages are:

- Collaboration to Advance Teaching Technology and Science (NSF GK-12, lead organization is University of Arizona)
- Investigating the Universe (NSF Instructional Materials, lead is Technical Education Research Centers, with NOAO and Astronomical Society of the Pacific)
- Spitzer Teacher and Student Research Program

3.9.3 Special topic: EPO Advisory Committee
At the request of the National Science Board, NOAO has formed an EPO Advisory committee, which met for the first time on 30–31 March 2009. This committee is charged with evaluating the direction and quality of the existing EPO program and is headed by Dr. Susana Deustua, former AAS Education Officer. Other committee members are: Marge Bardeen (Fermilab), Roy Gould (Harvard CfA), Lucy Fortson (Adler and University of Chicago), Kevin McLin (Sonoma State University), and Ken Brecher (Boston University).

The charge to the committee is:

- Review the design and effectiveness of current NOAO North and South astronomy education and public outreach programs, including their objectives, audiences, and deliverables, in order to evaluate their overall performance and value to their audiences
• Advise NOAO on the implementation of specific metrics that will show the overall program effectiveness
• Advise NOAO on future directions for the successful evolution of the EPO program
• Advise NOAO on the overall structure of its EPO portfolio of education projects (e.g., formal vs. informal) including the target audiences (e.g., age-level; program scope—local, regional, national, international audiences) with consideration of the budget pressures at NOAO
• Examine the current programs in a larger context of national research facility education programs to assess their relative intellectual merit and broader impacts as defined by NSF, their potential to reach diverse audiences, and their overall productivity with the resources allocated
• Advise NOAO on additional resources and partnerships that may be available for educational projects
• Submit a written report to the NOAO Director on the committee’s conclusions and findings

3.9.4 Major planned deliverables: FY 2009–2013
Major planned deliverables in this period include:
• FY 2009: Completion of the eight main and secondary deliverables described above; the first meeting of the EPO Advisory Committee; a series of Project ASTRO workshops in Tucson, Phoenix, and Prescott; a successful GLOBE at Night Dark Sky Education Campaign; delivery of the final Galileoscope design; training of museum education professionals nationally for Astronomy from the Ground Up; establishment of the Hands-On Optics program at eight Arizona Boys & Girls Club sites; maintenance of a vigorous education and outreach program at the CADIAS science center in Chile and with the Tohono O’odham Nation near Tucson
• FY 2010: Completion of the eight main and secondary deliverables described above; a series of Project ASTRO workshops in Tucson, Phoenix, and Prescott; maintenance of a vigorous education and outreach program at the CADIAS science center in Chile and with the Tohono O’odham Nation near Tucson; seek new outreach grant funding as time allows
• FY 2011: Same as FY 2010
• FY 2012: Same as FY 2010
• FY 2013: Same as FY 2010

3.9.5 Potential challenges and opportunities
The key challenge facing the EPO program is maintaining a national reputation for quality and service given the budget uncertainties. As grants end, the program must smoothly transition to core funding while maintaining the quality of the programs and the morale of the small core staff in the face of a heavy workload.
Another challenge is to maintain energetic media relations with no trained NOAO press or information officer. While this challenge can be met in the near-term with present staffing, expansion of this important function will be difficult due to resource limitations. As funding permits, NOAO needs to hire a full-time media relations expert.

NOAO has many opportunities in the EPO area. NOAO programs such as Hands-On Optics, Research Based Science Education, the Spitzer Teacher and Student Research Program, Project ASTRO, and GLOBE at Night are viewed as highly successful models by the EPO community. NOAO can play a key role in expanding these programs (e.g., the Galileoscope) or in training EPO professionals on how to implement these kinds of programs. Modest support from base funding (assuming an increase) and targeted grants will be needed.
4 Management plan

4.1 NOAO Director’s Office

4.1.1 Overview

The NOAO Director’s Office (NDO) provides high-level leadership, management, and budgetary control for the ensemble NOAO program. It is the main programmatic interface between NSF, AURA, and the rest of the NOAO management team. NDO is responsible ultimately for key documents such as the Annual Program Plan and the (annual) Long-Range Plan.

The NDO is lead by the NOAO Director and Deputy Director and supported by one dedicated, full-time administrative assistant. Part-time support from several Tucson-based administrative assistants is provided as needed with specific tasks (e.g., report generation and submission).

4.1.2 Risk Management Office

Risk management and safety functions are centralized within the NOAO Director’s Office under the NOAO Risk Manager, who is responsible for the development, direction, and administration of safety, health, security, and environmental programs and activities. He has supported other organizations when requested, including Gemini, CTIO/AOSS, NSO, and SOAR. Participation continues with LSST, ATST, and instrument groups by developing and completing risk management documents and other tasks in preparation for design and program reviews. In addition, he is responsible for managing AURA’s industrial insurance as the AURA Insurance Program Administrator and supports the Central Facilities Office as the Assistant Facilities Manager.

A monthly report is generated as well as site safety (risk management) reports required under the cooperative agreement that are published in the NOAO quarterly and annual reports.

4.1.3 Broadening participation

4.1.3.1 Overview

NSF has recently re-emphasized that broadening participation in the US science enterprise must be a key component for all NSF-supported programs. As summarized on the NSF Broadening Participation Web page, NSF has “established a performance area focused on broadening participation: to expand efforts to increase participation from underrepresented groups and diverse institutions throughout the United States in all NSF activities and programs [emphasis added].”

To further quote from Broadening Participation at the National Science Foundation: A Framework for Action (2008):

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7 www.nsf.gov/od/broadeningparticipation/bp.jsp
8 www.nsf.gov/od/broadeningparticipation/framework_report.jsp
Creating opportunities and developing innovative strategies to broaden participation among diverse individuals, institutions, and geographic areas are critical to the NSF mission of identifying and funding work at the leading edge of discovery. The creative engagement of diverse ideas and perspectives is essential to enabling the transformative research that invigorates our nation’s scientific and engineering enterprise. Broadening participation infuses science and engineering excellence into varied individual, institutional, and geographic networks and provides for the discovery and nurturing of talent wherever it may be found.

NSF defines broadening participation in terms of individuals from underrepresented groups as well as institutions and geographic areas that do not participate in NSF research programs at rates comparable to others.

NOAO takes this charge extremely seriously and has taken two key actions.

First, NOAO is participating in the development and implementation of the AURA-wide plan for broadening participation. The AURA/NOAO commitment to broadening participation is captured in this mission statement:

As a leader in the astronomical community, AURA [added: and by extension NOAO] believes that it bears a responsibility to that community to develop and support outreach and educational programs which will not only advance our organizational commitment to diversity but broadens participation and encourages the advancement of diversity throughout the astronomical scientific workforce.

In support of this commitment, NOAO has appointed two Diversity Co-Advocates who report to the NOAO Director. Broadly speaking, their mission is to advocate for broadening participation initiatives across all of NOAO. In practice, the NOAO Director has asked them to focus, at least initially, on three key issues:

- Work place climate issues for women scientists and engineers at NOAO.
- Recruitment and retention of underrepresented individuals for the NOAO scientific and technical workforce.
- Recruitment and retention of underrepresented individuals through the educational pipeline from undergraduate to post-doctoral fellowships. Obviously, NOAO cannot and will not solve the entire “pipeline problem.” But, we can support such efforts.

The NOAO EPO program is already focused on science education for underrepresented groups at the K-12 level, as discussed earlier in this document. Obviously, NOAO efforts in these areas can and will evolve in the years ahead.
4.1.3.2 Research Experiences for Undergraduates

The Research Experiences for Undergraduates (REU) programs at KPNO and CTIO offer undergraduate students the opportunity to engage in challenging research activities with scientists working at the forefront of astronomy and astrophysics. Each year twelve REU students (six at NOAO North and six at NOAO South) are hired as full-time research assistants to work with NOAO staff members on selected research projects for a period of ten to twelve weeks over the summer.

As part of their research activities, REU students gain first-hand experience with state-of-the-art telescopes and instrumentation, and develop expertise in the tools of data analysis specific to astronomical research. Careful matching of the expressed scientific interests of the individual applicant with the research needs and expertise of the individual REU mentor accounts for the success of previous NOAO REU site programs—as measured by the high percentage of former participants who have gone on to graduate school in astrophysics or have pursued a career in the science, education, and technology workforce, as well as the impressive number of research papers and articles published by former students.

In an effort to achieve broader diversity in the NOAO REU programs, the REU Site Directors will work closely with the NOAO Diversity Co-Advocates with the goal of getting more underrepresented minority students to apply to the NOAO REU program.

4.1.3.3 Partnerships in Astronomy & Astrophysics Research and Education

NOAO has recently started to engage with the NSF-funded Partnerships in Astronomy & Astrophysics Research and Education (PAARE) program. The NOAO partnership (A Partnership in Observational and Computational Astronomy, POCA) is with Professor Don Walter of South Carolina State University (SCSU), a Historically Black
College/University (HBCU). The first NOAO POCA undergraduate student, Patrick Durant (SCSU), will spend the summer of 2009 at NOAO North; he will be mentored by Steve Howell and will be working with the KPNO and NSO REU students from June through mid-August.

NOAO has partnered with Fisk University (another HBCU) in a five-year PAARE proposal Graduate Opportunities at Fisk in Astronomy and Astrophysics Research (GO-FAAR) (PI: Keivan Stassun). That proposal is currently under review. NOAO will provide up to eight PAARE mentors each year (four per year in both hemispheres) to work with minority PAARE undergraduates. NOAO envisions the PAARE students working side-by-side with NOAO REU undergraduate students and their mentors, under the guidance and supervision of the NOAO REU Site Directors.

### 4.2 Executive Committee

The NOAO Executive Committee (EC) is the senior management committee that advises the NOAO Director. It is composed of the managers of the programs in Figure 1.

Current EC members are:

<table>
<thead>
<tr>
<th>Program</th>
<th>Title</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOAO</td>
<td>Director</td>
<td>David Silva</td>
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<tr>
<td>NOAO</td>
<td>Deputy Director</td>
<td>Robert Blum</td>
</tr>
<tr>
<td>Admin. &amp; Facilities</td>
<td>Associate Director</td>
<td>Karen Wilson</td>
</tr>
<tr>
<td>KPNO</td>
<td>Associate Director</td>
<td>Buell Jannuzi</td>
</tr>
<tr>
<td>NOAO S (CTIO++)</td>
<td>Associate Director</td>
<td>R. Chris Smith</td>
</tr>
<tr>
<td>NSSC</td>
<td>Associate Director</td>
<td>Verne Smith</td>
</tr>
<tr>
<td>NSTC</td>
<td>Head of Program</td>
<td>David Sprayberry</td>
</tr>
<tr>
<td>OS</td>
<td>Head of Program</td>
<td>George Jacoby (interim)</td>
</tr>
<tr>
<td>EPO</td>
<td>Head of Program</td>
<td>Stephen Pompea</td>
</tr>
</tbody>
</table>

The EC meets face-to-face roughly twice per month. The NOAO Director invites other people to these meetings as appropriate. Currently, Science Data Management (Betty Stobie) and LSST Project Office (Victor Krabbendam) have a standing invitation to attend EC meetings.

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9 The five-year POCA program (A Partnership in Observational and Computational Astronomy) (PI: Don Walter) is funded by the NSF through the grant AST-0750814.

10 Jacoby has requested that he be re-assigned to a technology development program after 2009.
4.3 External committees
NOAO senior managers spend significant time annually interacting with external committees. A brief description of each committee is provided below.

4.3.1 Formal oversight

4.3.1.1 AURA Board of Directors
This is the most senior management council for AURA as a whole. To quote from the AURA Board Web site:\footnote{AURA Board of Directors Web site: www.aura-astronomy.org/g/ag.asp?gid=82}

The Board, which meets quarterly, establishes the policies of AURA, approves its budget, elects members of the Management Councils, and appoints the President, the Center Directors, and other principal officers. The Board of Directors is responsible to the Member Representatives for the effective management of AURA and the achievement of its purposes.

The NOAO Director attends all AURA Board meetings in person, except under extraordinary circumstances. Other NOAO senior managers attend as necessary, but infrequently. One of these meetings coincides with the AURA Representatives Council (see below).

4.3.1.2 AURA Member Representatives
Each AURA institution is represented by one Member Representative. These Member Representatives meet once per year to discuss global AURA matters, elect the Board of Directors, etc. This multi-day meeting is attended by the NOAO Director and Deputy Director as well as the Associate Directors for Administration and Facilities, KPNO, and CTIO. Other NOAO managers may attend as necessary.

4.3.1.3 AURA Observatory Council
Appointed by the AURA Board, the Observatory Council (OC) provides oversight and advocacy for the management of NOAO. In particular, the OC reviews the NOAO Annual Program Plan and the NOAO Long-Range Plan as well as the performance of senior managers. The OC meets in person twice per year. These meetings are attended by the entire NOAO EC and other invitees as appropriate. Separate teleconferences are held on an as-needed basis.

4.3.1.4 NSF Program Review Panel
Appointed by the NSF Astronomy Division, the Program Review Panel (PRP) meets twice per year to review NOAO management activities. The PRP is appointed by NSF AST and reports directly to them. Like the AURA OC, the NSF PRP reviews and comments on the Annual Program Plan and the Long-Range Plan. It also reviews all actions taken by NOAO to respond to various NSF directives and obligations, especially those called out in the AURA cooperative agreement. The NOAO Director always
attends these meetings. The NOAO Deputy Director and Associate Director for Administration and Facilities attend these meetings as necessary.

4.3.2 Advisory

4.3.2.1 Time Allocation Committee
The TAC reviews observing proposals for all of the System’s open-access time administered by NOAO, including NOAO facilities. Based on this review, a scientifically ranked list of observing proposals is forwarded to the NOAO Director for scheduling. In principle, TAC recommendations and priorities are only advisory to the NOAO Director. In practice, it is extremely rare for the NOAO Director to modify TAC recommendations.

Details of the TAC process can be found at www.noao.edu/gateway/tac.

4.3.2.2 NOAO User’s Committee
Appointed by the NOAO Director, the NOAO User’s Committee (UC) holds an annual face-to-face meeting to advise the Director on all matters related to the scientific use of the System’s open-access facilities, with a particular focus on NOAO facilities. The entire NOAO EC attends these meetings, and most EC members make presentations.

Further details, including UC membership, can be found at www.noao.edu/dir/usercom/.

4.3.2.3 US Gemini Science Advisory Committee
NOAO meets semi-annually with the US Gemini Science Advisory Committee (SAC) to discuss the US perspective on all matters that bear on the scientific quality and productivity of the Gemini Observatory. The NSSC (NGSC) Associate Director attends these meetings. The NOAO Director and Deputy Director attend as time permits.

The current membership for the US Gemini SAC can be found at www.noao.edu/usgp/committees.html.

4.3.2.4 NOAO EPO Advisory Committee
Newly created for FY 2009, this committee has been charged with evaluating the direction and quality of the existing EPO program. The NOAO Deputy Director and EPO Head of Program will attend these meetings.
4.3.3 Partnership boards

4.3.3.1 Large Synoptic Survey Telescope
NOAO is an LSST Founding Member. The NOAO Director is a member of the LSST Board of Directors. The Board has monthly teleconferences and quarterly face-to-face meetings. Currently, the NOAO Director serves as the LSST Corporation Treasurer.

More information about LSST governance can be found at www.lsst.org/lsst/about/team.

4.3.3.2 Wisconsin-Indiana-Yale-NOAO (WIYN) Observatory
NOAO is a 40% partner of the WIYN Corporation and has three seats on the WIYN Board. These seats are filled by the KPNO Associate Director and two other NOAO scientists.

4.3.3.3 Southern Observatory for Astronomical Research
NOAO is a member of the SOAR Consortium and has three seats on the SOAR Board. These seats are filled by the NOAO South (CTIO) Associate Director and two other NOAO scientists.

4.3.3.4 AURA Coordinating Council of Observatory Research Directors
The purpose of the Coordinating Council of Observatory Research Directors (ACCORD) is to “facilitate progress in U. S. ground-based optical and infrared astronomy by providing, under the auspices of AURA, a mechanism for mutually beneficial cooperation among the operators of major observing facilities.” The NOAO Director is the ACCORD Co-Chair and attends all meetings, which occur at least once per year.

4.3.3.5 Dark Energy Survey Directors’ Council
The Dark Energy Survey (DES) is a major scientific experiment that will consume 525 nights over five years on the Blanco 4-m telescope. In return for those nights, the DES Project will deliver a 3-square-degree optical camera for the Blanco telescope and a data processing pipeline. The DES Directors’ Council provides top-level management oversight. Members of the DES Directors’ Council are the directors from Fermi National Accelerator Laboratory, National Center for Supercomputing Applications, and NOAO. The Council meets face-to-face semi-annually with regular teleconferences in-between.

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12 The LSST Founding Members are: NOAO, Research Corporation, University of Arizona, and University of Washington.
13 AURA ACCORD Web site: www.aura-astronomy.org/g/ag.asp?gid=68
5  Budget projection

5.1  Planned NSF program support

At the recommendation of NSF, LRP budget planning assumed \textit{ab initio} that the FY 2009 core funding would be $27.7M and NOAO core funding would grow by 3\% per year. These numbers are consistent with high-level assumptions in the recently approved AURA cooperative agreement renewal proposal. The envelope defined by these two numbers is called Total NSF Program Support (Planned) in Tables 1 and 2 (located at the end of this document).

Organizational structure changes described elsewhere in this document require that the top-level NOAO budget envelope be distributed differently than in previous years and differently than what was proposed in the most recent AURA cooperative agreement renewal proposal. As described earlier in this document, most of those changes were driven by the outcome of discussions with NSB/NSF who insisted on various changes as a condition for approval of the cooperative agreement. Changes were also required to reflect revised plans for NOAO administration and facilities support to the National Solar Observatory during this period.

Table 1 shows the planned distribution of (core) NSF program support. Table 2 shows the actual spend plan. In each fiscal year:

\[
\text{Total NOAO Program Spend Plan} = \text{Total Program Revenue} + \text{Total NSF Program Support (Planned)}
\]

Table 3 provides details for projected sources of \textit{Total Program Revenue} (above NSF base funding), i.e., revenue generated from non-NSF sources.

In all fiscal years, the NOAO spend plan has been forced to be exactly equal to expected NSF support plus expected revenues. The use of carry-forward money from previous years has not been used to balance the NOAO budget. If cost savings or other events do result in year-to-year unspent funding, NOAO intends to use it for long-term capital investment in a to-be-determined mix of NOAO science capabilities and infrastructure improvements, not for commitments that create long-term budget obligations (for example, hiring staff personnel faster than the replacement rate).

For the most part, the spend plan for FY 2010–2013 is merely a continuation of the FY 2009 spend plan plus inflation. Adjustments have been made for known major events including: (1) a required increase allocation of NSF base support to Kitt Peak and Cerro Tololo to cover loss of revenue from terminated telescope and instrument partnerships; and (2) decreased NSF base support to the LSST program after the (assumed) construction start in FY 2012. Various other minor adjustments were made.
At least four mid-term strategic issues have not been addressed yet:

1. Neither KPNO nor NOAO South/CTIO has enough funding yet to deal smoothly and strategically with the need to train new staff to prepare for upcoming retirements of current staff and the arrival of a new generation of 4-m class instrumentation.

2. The number of NOAO science staff in La Serena has become sub-critical due to the movement of NOAO science staff from South to North in recent years.

3. Staff benefit costs (especially medical) are expected to increase faster than core inflation. Over time, this means that pressure on the non-staff side of the NOAO budget may increase faster than projected NSF core funding.

4. Continued and unpredictable fluctuations in the exchange rate between US dollars and Chilean pesos, as well as the overall Chilean inflation rate.

A strategic Director’s Reserve (see Tables 1 and 2) has been budgeted so that NOAO has some year-by-year discretion to deal with such base program challenges as they arise without disrupting the rest of the NOAO program. Of course, NSF funding must be large enough to allow the existence of such a reserve. Furthermore, over time, the Director’s Reserve becomes consumed if the other funding cannot be found and/or reprogrammed to deal with such problems.

Note that the Director’s Reserve increases significantly in FY 2012 under the assumption that some LSST Project costs transition from NOAO base funding to construction funding. Whether or not that really occurs will not be known for at least another 12 months.

5.2 Expected NSF program support and implications

Late April 2009: actual NSF budget allocation numbers remain uncertain.

5.2.1 Stimulus

In general terms, two things are known. First, “multiple millions” will be allocated to NOAO from NSF stimulus funding. NOAO assumes a range of $2–10M. Second, stimulus funding will be targeted towards infrastructure deferred maintenance catch-up and/or improvement projects. Science capability new-starts will not be allowed. This is very good news in terms of fixing various point-problems. However, direct stimulus funding is a one-time event and will have little long-term impact on the NOAO base operations budget.

Indirectly, NOAO and its ReSTAR Phase 1 partners may also benefit from stimulus funding if such funds can be used by NSF to support the ReSTAR Phase 1 implementation proposal.
5.2.2 FY 2009

NOAO has been told to expect final FY 2009 funding to be greater than FY 2008 (i.e., above the Continuing Resolution level) but less than the original President’s Request level of $27.7M. Hence, the NSF base (core) funding assumption for FY 2009 ($27.7M; see tables below and approved AURA cooperative agreement) is too optimistic.

An alternative NSF funding model is shown in Table 2. Called Total NSF Program Support (Expected), this model assumes $26.2M in FY 2009, which is simply the average of $24.6M (FY 2008 allocation) and $27.7M (original President’s Request). This is an assumption without any explicit or implied commitment from NSF. In this alternative model, if the Director’s Reserve is completely spent, NOAO (projected) expenditures fall short by $459K for FY 2009.

Carry-forward from FY 2008 is available to cover this shortfall. However, it would be much more desirable to use carry-forward for strategic capital improvements rather than covering base operations expenditures.

5.2.3 FY 2010

A top-level summary of the FY 2010 President’s Budget Request was tabled 26 February 2009. In that document, the NSF budget was projected to grow from $6.1B (FY 2008) to $6.9B (FY 2009) to $7.0B (FY 2010). That is a 14.7% increase relative to FY 2008 but only a 1.4% increase relative to FY 2009. Hence, the assumption that the NOAO base budget will grow by 3% per year (see tables below and approved AURA cooperative agreement) is likely too optimistic.

In the alternative model shown in Table 2, the assumed FY 2009 NSF base funding ($26.2M) is increased by 1.5% to $26.6M. If the Director’s Reserve is completely spent, NOAO (projected) expenditures fall short by $938K in FY 2010.

Carry-forward from FY 2008 could also cover this shortfall. However, it would be much more desirable to use carry-forward for capital improvements rather than covering base operations expenditures.

5.2.4 FY 2011–2013

From FY 2011 forward, the alternative (“expected”) NSF support model in Table 2 assumes 3% annual increases, following the standard (“planned”) NSF support model. If the Director’s Reserve is completely spent in FY 2011, NOAO (projected) expenditures fall short by $966K. Today, there is no obvious way to cover this shortfall. Smaller shortfalls exist in FY 2012 and FY 2013.

5.2.5 Implications

Without changes, the alternative (“expected”) NSF support model does not create a healthy situation for NOAO. At least three things must happen in the near-term.
1. NSF must decide if they can or cannot afford to support the strategic vision for the NOAO base program expressed in this document. Based on that decision, NSF should provide NOAO with clear funding guidance and support over 3–5 years.

2. In the next 12–18 months, NOAO must review its entire budget including all expenditures and non-NSF revenues. Based on this review, a strategic plan must be created to fit NOAO expenditures within expected NSF funding and non-NSF revenues while accounting for known strategic issues (e.g., retirements). Based on NSF input (Item 1), it is possible this plan will lead to the reduction or elimination of some NOAO programs.

3. NSF must decide what NOAO supplementary programs to support, especially ReSTAR, TSIP, LSST, and GSMT.
## Acronyms List

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
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<tbody>
<tr>
<td>AAS</td>
<td>American Astronomical Society</td>
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<tr>
<td>ACCORD</td>
<td>AURA Coordinating Council of Observatory Research Directors</td>
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<tr>
<td>ALTAIR</td>
<td>Access to Large Telescopes for Astronomical Instruction and Research</td>
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<tr>
<td>AOSS</td>
<td>AURA Observatory Support Services</td>
</tr>
<tr>
<td>AST</td>
<td>Astronomical Sciences (Division of NSF)</td>
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<tr>
<td>ATST</td>
<td>Advanced Technology Solar Telescope</td>
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<tr>
<td>AURA</td>
<td>Association of Universities for Research in Astronomy</td>
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<tr>
<td>AURA-O</td>
<td>AURA Observatory in Chile</td>
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<tr>
<td>CADIAS</td>
<td>Centro de Apoyo a la Didáctica de la Astronomía</td>
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<tr>
<td>CAS</td>
<td>Central Administrative Services</td>
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<tr>
<td>CCD</td>
<td>Charge-coupled Device</td>
</tr>
<tr>
<td>CFO</td>
<td>Central Facilities Operations</td>
</tr>
<tr>
<td>CIS</td>
<td>Computer Infrastructure Services</td>
</tr>
<tr>
<td>CTIO</td>
<td>Cerro Tololo Inter-American Observatory</td>
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<tr>
<td>CXO</td>
<td>Chandra X-ray Observatory</td>
</tr>
<tr>
<td>DCT</td>
<td>Discovery Channel Telescope</td>
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<tr>
<td>DECam</td>
<td>Dark Energy Camera</td>
</tr>
<tr>
<td>DES</td>
<td>Dark Energy Survey</td>
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<tr>
<td>DOE</td>
<td>Department Of Energy</td>
</tr>
<tr>
<td>E2E</td>
<td>End-to-End</td>
</tr>
<tr>
<td>EC</td>
<td>Executive Committee</td>
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<tr>
<td>ELT</td>
<td>Extremely Large Telescope</td>
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<tr>
<td>EPO</td>
<td>Education and Public Outreach</td>
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<tr>
<td>ETS</td>
<td>Engineering and Technical Services</td>
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<tr>
<td>FERMI</td>
<td>Fermi National Accelerator Laboratory</td>
</tr>
<tr>
<td>FWHM</td>
<td>Full width half-maximum</td>
</tr>
<tr>
<td>FY</td>
<td>Fiscal Year</td>
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<tr>
<td>GALEX</td>
<td>Galaxy Evolution Explorer</td>
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<tr>
<td>Gbps</td>
<td>Gigabits per second</td>
</tr>
<tr>
<td>GK-12</td>
<td>Grades K through 12</td>
</tr>
<tr>
<td>GMT</td>
<td>Giant Magellan Telescope</td>
</tr>
<tr>
<td>GONG</td>
<td>Global Oscillation Network Group</td>
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<tr>
<td>GSMT</td>
<td>Giant Segmented Mirror Telescope</td>
</tr>
<tr>
<td>HBCU</td>
<td>Historically Black College/University</td>
</tr>
<tr>
<td>Acronym</td>
<td>Definition</td>
</tr>
<tr>
<td>---------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>HR</td>
<td>Human Resources</td>
</tr>
<tr>
<td>HST</td>
<td>Hubble Space Telescope</td>
</tr>
<tr>
<td>HVAC</td>
<td>Heating, Ventilating, Air Conditioning</td>
</tr>
<tr>
<td>IQ</td>
<td>Image quality</td>
</tr>
<tr>
<td>IR</td>
<td>Infrared</td>
</tr>
<tr>
<td>IRAF</td>
<td>Image Reduction and Analysis Facility</td>
</tr>
<tr>
<td>ISE</td>
<td>Informal Science Education</td>
</tr>
<tr>
<td>IT</td>
<td>Information Technology</td>
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<tr>
<td>K-12</td>
<td>K through 12</td>
</tr>
<tr>
<td>KPENG</td>
<td>Kitt Peak Engineering</td>
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<tr>
<td>KPNO</td>
<td>Kitt Peak National Observatory</td>
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<tr>
<td>KPVC</td>
<td>Kitt Peak Visitor Center</td>
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<tr>
<td>LBT</td>
<td>Large Binocular Telescope</td>
</tr>
<tr>
<td>LCOGTN</td>
<td>Las Cumbres Observatory Global Telescope Network</td>
</tr>
<tr>
<td>LRP</td>
<td>Long-Range Plan</td>
</tr>
<tr>
<td>LSST</td>
<td>Large Synoptic Survey Telescope</td>
</tr>
<tr>
<td>LSSTC</td>
<td>Large Synoptic Survey Telescope Corporation</td>
</tr>
<tr>
<td>MMT</td>
<td>Multiple Mirror Telescope</td>
</tr>
<tr>
<td>MREFC</td>
<td>Major Research Equipment and Facility Construction</td>
</tr>
<tr>
<td>NASA</td>
<td>National Aeronautics and Space Administration</td>
</tr>
<tr>
<td>NDO</td>
<td>National Optical Astronomy Observatory’s Director’s Office</td>
</tr>
<tr>
<td>NEWFIRM</td>
<td>NOAO Extremely Wide-Field Infrared Imager</td>
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<tr>
<td>NGSC</td>
<td>NOAO Gemini Science Center</td>
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<tr>
<td>NOAO</td>
<td>National Optical Astronomy Observatory</td>
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<tr>
<td>NRAO</td>
<td>National Radio Astronomy Observatory</td>
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<tr>
<td>NSB</td>
<td>National Science Board</td>
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<tr>
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<td>National Science Foundation</td>
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<tr>
<td>NSO</td>
<td>National Solar Observatory</td>
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<tr>
<td>NSSC</td>
<td>NOAO System Science Center</td>
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<tr>
<td>NSTC</td>
<td>NOAO System Technology Center</td>
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<tr>
<td>O/IR</td>
<td>Optical and Infrared</td>
</tr>
<tr>
<td>OC</td>
<td>Observatory Council</td>
</tr>
<tr>
<td>ODI</td>
<td>One Degree Imager</td>
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<tr>
<td>OS</td>
<td>Office of Science</td>
</tr>
<tr>
<td>OSMOS</td>
<td>Ohio State MultiObject Spectrograph</td>
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<tr>
<td>PAARE</td>
<td>Partnerships in Astronomy &amp; Astrophysics Research and Education</td>
</tr>
<tr>
<td>Acronym</td>
<td>Definition</td>
</tr>
<tr>
<td>---------</td>
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</tr>
<tr>
<td>PAEO</td>
<td>Public Affairs and Educational Outreach</td>
</tr>
<tr>
<td>Pan-STARRS</td>
<td>Panoramic Survey Telescope &amp; Rapid Response System</td>
</tr>
<tr>
<td>PBX</td>
<td>Private Branch Exchange</td>
</tr>
<tr>
<td>PI</td>
<td>Principal Investigator</td>
</tr>
<tr>
<td>POCA</td>
<td>A Partnership in Observational and Computational Astronomy</td>
</tr>
<tr>
<td>PROMPT</td>
<td>Panchromatic Robotic Optical Monitoring and Polarimetry Telescopes</td>
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<tr>
<td>PRP</td>
<td>Program Review Panel</td>
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<tr>
<td>ReSTAR</td>
<td>Renewing Small Telescopes for Astronomical Research</td>
</tr>
<tr>
<td>REU</td>
<td>Research Experiences for Undergraduates</td>
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<tr>
<td>SAC</td>
<td>Science Advisory Committee</td>
</tr>
<tr>
<td>SAM</td>
<td>SOAR Adaptive-Optics Module</td>
</tr>
<tr>
<td>SCD</td>
<td>System Community Development</td>
</tr>
<tr>
<td>SCSU</td>
<td>South Carolina State University</td>
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<tr>
<td>SDM</td>
<td>Science Data Management</td>
</tr>
<tr>
<td>SDM-D</td>
<td>System Data Management Systems Development</td>
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<tr>
<td>SDM-O</td>
<td>System Data Management Systems Operations</td>
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<tr>
<td>SI</td>
<td>System Instrumentation</td>
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<tr>
<td>SMARTS</td>
<td>Small and Moderate Aperture Research Telescope System</td>
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<tr>
<td>SOAR</td>
<td>Southern Observatory for Astronomical Research</td>
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<tr>
<td>SOLIS</td>
<td>Synoptic Optical Long-Term Investigations of the Sun</td>
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<tr>
<td>SPO 1</td>
<td>Scientific Program Order 1</td>
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<tr>
<td>STEM</td>
<td>Science, Technology, Engineering, and Math</td>
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<tr>
<td>SUS</td>
<td>System User Support</td>
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<tr>
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<td>Time Allocation Committee</td>
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<td>TMT</td>
<td>Thirty Meter Telescope</td>
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<tr>
<td>TSIP</td>
<td>Telescope System Instrumentation Program</td>
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<tr>
<td>UC</td>
<td>User’s Committee</td>
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<tr>
<td>US</td>
<td>United States of America</td>
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<tr>
<td>VAO</td>
<td>Virtual Astronomical Observatory</td>
</tr>
<tr>
<td>VoIP</td>
<td>Voice over Internet Protocol</td>
</tr>
<tr>
<td>VPH</td>
<td>Volume-phase holographic</td>
</tr>
<tr>
<td>WHAM</td>
<td>Wisconsin H-Alpha Mapper</td>
</tr>
<tr>
<td>WIYN</td>
<td>Consortium consisting of University of Wisconsin, Indiana University, Yale, and NOAO</td>
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