

National Optical Astronomy Observatory Long Range Plan: FY 2011 - 2015



NOAO is operated by Association of Universities for Research in Astronomy (AURA), Inc. under cooperative agreement with the National Science Foundation (NSF)

Table of Contents

NOAO Mission Profile.....	1
1 Introduction.....	2
1.1 Overview.....	2
1.2 NOAO and the US Ground-Based O/IR System	2
1.3 NOAO at the Science Frontiers of the 2010 Decadal Survey	3
1.4 High-Level Deliverables: Highlights	5
1.4.1 NSF base funding.....	5
1.4.2 NSF supplementary funding.....	6
1.5 NOAO Strategic Vision: Background Documents.....	7
2 High-Level LRP Development Framework	9
2.1 Strategic Principles.....	9
2.2 High-Level Planning Assumptions	10
2.3 ReSTAR: Renewing Small Telescopes for Astronomical Research.....	11
2.3.1 ReSTAR Phase 1 (ReSTAR-1).....	11
2.3.2 ReSTAR Phase 2 (ReSTAR-2).....	11
2.4 ALTAIR: Access to Large Telescopes for Astronomical Instruction and Research.....	12
2.5 Partnerships with Emerging International Astronomy Communities.....	13
2.6 NOAO and Official National Priorities	14
3 Top-Level NOAO Organization	16
4 NOAO Divisions.....	17
4.1 NOAO North.....	17
4.1.1 Overview.....	17
4.1.2 Kitt Peak National Observatory.....	17
4.1.2.1 Overview.....	17
4.1.2.2 Major activities.....	18
4.1.2.3 Major planned deliverables.....	19
4.1.2.4 Special topic: BigBOSS.....	19
4.1.2.5 Anticipated challenges and opportunities	20
4.1.3 NOAO North Engineering and Technical Services	20
4.1.3.1 Overview.....	20
4.1.3.2 Major activities.....	21
4.1.3.3 Major planned deliverables.....	21
4.1.3.4 Anticipated challenges and opportunities	21
4.1.4 NOAO North Facility Operations	21
4.1.4.1 Overview.....	21
4.1.4.2 Major activities.....	22
4.1.4.3 Major planned deliverables.....	23
4.1.4.4 Special topic: renewal of NOAO-Tucson facility.....	23

NOAO Long-Range Plan 2011

4.1.4.5	Special topic: renovation/expansion of Tucson downtown facility.....	24
4.1.4.6	Special topic: ARRA work at NOAO North	24
4.1.4.7	Anticipated challenges and opportunities	25
4.2	NOAO South.....	25
4.2.1	Overview.....	25
4.2.2	Cerro Tololo Inter-American Observatory	26
4.2.2.1	Overview.....	26
4.2.2.2	Major activities.....	26
4.2.2.3	Major planned deliverables.....	27
4.2.2.4	Special topic: Dark Energy Survey/Dark Energy Camera.....	28
4.2.2.5	Anticipated challenges and opportunities	28
4.2.3	NOAO South Engineering and Technical Services	29
4.2.3.1	Overview.....	29
4.2.3.2	Major activities.....	29
4.2.3.3	Major planned deliverables.....	29
4.2.3.4	Anticipated challenges and opportunities	30
4.2.4	NOAO South Facility Operations	30
4.2.4.1	Overview.....	30
4.2.4.2	Major activities.....	30
4.2.4.3	Major planned deliverables.....	31
4.2.4.4	Special topic: renewal of NOAO South downtown facility	31
4.2.4.5	Special topic: ARRA work at NOAO South.....	31
4.2.4.6	Anticipated challenges and opportunities	32
4.2.5	NOAO South Administration.....	33
4.2.5.1	Overview.....	33
4.2.5.2	Major activities.....	33
4.2.5.3	Major planned deliverables.....	33
4.2.5.4	Anticipated challenges and opportunities	34
4.3	NOAO System Science Center.....	34
4.3.1	Overview.....	34
4.3.2	System User Support.....	35
4.3.2.1	Overview.....	35
4.3.2.2	Major activities.....	35
4.3.2.3	Major planned deliverables.....	36
4.3.2.4	Anticipated challenges and opportunities	36
4.3.3	System Community Development.....	37
4.3.3.1	Overview.....	37
4.3.3.2	Major activities.....	37
4.3.3.3	Major planned deliverables.....	38
4.3.3.4	Anticipated challenges and opportunities	38
4.3.4	Science Data Management.....	38
4.3.4.1	Overview.....	38
4.3.4.2	Major activities.....	38
4.3.4.3	Major planned deliverables.....	39
4.3.4.4	Anticipated challenges and opportunities	39
4.3.5	TAC Team.....	40
4.3.5.1	Overview.....	40
4.4	NOAO System Technology Center	40
4.4.1	Overview.....	40
4.4.2	System Instrumentation.....	41
4.4.2.1	Overview.....	41

4.4.2.2	Major activities.....	42
4.4.2.3	Major planned deliverables.....	43
4.4.3	Telescope System Instrumentation Program	43
4.4.3.1	Overview.....	43
4.4.3.2	Major activities.....	44
4.4.3.3	Major planned deliverables.....	44
4.4.4	NOAO LSST Program.....	44
4.4.4.1	Overview.....	44
4.4.4.2	Major activities.....	45
4.4.4.3	Major planned deliverables.....	46
4.4.5	GSMT/ELT Technology	46
4.4.5.1	Overview.....	46
4.4.5.2	Major activities.....	47
4.4.5.3	Major planned deliverables.....	47
4.4.6	Anticipated challenges and opportunities	47
4.4.7	Special topic: development of instrumentalists	47
4.4.7.1	ReSTAR subprogram: instrumentation internships.....	47
4.4.7.2	Technology post-docs	48
4.5	NOAO Directorate	48
4.5.1	Overview.....	48
4.5.2	NOAO Director’s Office.....	48
4.5.2.1	Overview.....	48
4.5.2.2	Support offices	48
4.5.3	Central Administrative Services.....	49
4.5.3.1	Overview.....	49
4.5.3.2	Major activities.....	49
4.5.3.3	Major planned deliverables.....	50
4.5.3.4	Anticipated challenges and opportunities	51
4.5.4	Human Resources	51
4.5.4.1	Overview.....	51
4.5.4.2	Major planned deliverables.....	51
4.5.4.3	Anticipated challenges and opportunities	51
4.5.5	Office of Science	51
4.5.5.1	Overview.....	51
4.5.5.2	Major activities.....	52
4.5.5.3	Major planned deliverables.....	52
4.5.5.4	Anticipated challenges and opportunities	52
4.5.6	Broadening participation.....	53
4.5.6.1	NOAO Diversity Advocates	54
4.5.6.2	NOAO and REU	54
4.5.6.3	NOAO and PAARE	55
4.5.7	Education and Public Outreach	56
4.5.7.1	Overview.....	56
4.5.7.2	Major activities.....	56
4.5.7.3	Major planned deliverables.....	57
4.5.7.4	Special topic: Update on EPO Advisory Committee.....	58
4.5.7.5	Anticipated challenges and opportunities	58
5	Management Plan	59
5.1	Executive Council.....	59
5.2	External Committees	59
5.2.1	Formal oversight	60

NOAO Long-Range Plan 2011

5.2.1.1	AURA Board of Directors	60
5.2.1.2	AURA Member Representatives	60
5.2.1.3	AURA Observatory Council.....	60
5.2.1.4	NSF Program Review Panel.....	60
5.2.2	Advisory	60
5.2.2.1	Time Allocation Committee.....	60
5.2.2.2	NOAO User's Committee	61
5.2.2.3	US Gemini Science Advisory Committee.....	61
5.2.2.4	NOAO EPO Advisory Committee	61
5.2.3	Partnership boards.....	61
5.2.3.1	Large Synoptic Survey Telescope (LSST)	61
5.2.3.2	Wisconsin-Indiana-Yale-NOAO (WIYN) Observatory.....	61
5.2.3.3	Southern Observatory for Astronomical Research (SOAR)	61
5.2.3.4	AURA Coordinating Council of Observatory Research Directors	62
5.2.3.5	Dark Energy Survey Directors' Council.....	62
5.3	Reports	62
5.3.1	Reports required by NSF.....	62
5.3.2	Other scheduled reports.....	62
6	Challenges.....	63
6.1	FY 2011 Challenges	63
6.1.1	Financial (potential).....	63
6.1.2	Programmatic	63
6.2	Mid-Term Challenges	64
7	Budget Projection	65
7.1	FY 2011	65
7.2	FY 2012	65
7.3	Out Years: FY 2013–2015.....	67
7.4	Assumed Funding in Current Cooperative Agreement vs. Reality	68
8	NOAO Tenant Observatories (April 2011).....	69
9	Acronym List.....	71

Table of Figures

Figure 1: The US O/IR System	2
Figure 2: NOAO top-level organization chart.....	16
Figure 3: Kitt Peak.....	17
Figure 4: Cerro Tololo.....	25
Figure 5: Cerro Pachón.....	26
Figure 6: NOAO System Science Center (NSSC)	35
Figure 7: NOAO System Technology Center (NSTC)	40
Figure 8: SOAR Adaptive-Optics Module (SAM)	41
Figure 9: TripleSpec.....	43
Figure 10: Large Synoptic Survey Telescope (LSST)	45
Figure 11: 2010 REU cohorts.....	55

NOAO Mission Profile

The National Optical Astronomy Observatory (NOAO) is the US national research and development center for ground-based nighttime astronomy. Its core mission is to provide access for all qualified professional researchers to state-of-the-art scientific capabilities via peer review. Through that access, the US research community is investigating a broad range of modern astrophysical challenges from small bodies within our own Solar System, to the most distant galaxies in the early universe, to indirect observations of dark energy and dark matter.

To support that mission and help further US leadership in the international arena, NOAO is leading the development of the US Ground-Based Optical/Infrared (O/IR) System—the ensemble of public and private observatories dedicated to international leadership in scientific research, technical innovation, education, and public outreach.

NOAO is also leading programs that help enable a new generation of telescopes, instruments, and software tools to meet the research challenges of the next decade. In particular, NOAO is leveraging in-house scientific and technical expertise gained over 50 years to participate in the development of the Large Synoptic Survey Telescope, a unique 8-m-class, wide-field imaging telescope. Together, these new capabilities will enable the users of NOAO facilities to continue world-leading research on such diverse topics as the effects of dark energy over cosmological distances, the nature of stellar systems harboring earth-like exoplanets, and the nature of a more complete census of minor bodies within our own Solar System. By pushing back the frontiers of our understanding, users of NOAO facilities will also surely uncover cosmic phenomena unforeseen today.

To communicate the excitement and opportunities of world-class scientific research and technology development, NOAO operates a nationally recognized Education and Public Outreach (EPO) program. The NOAO EPO program strives to promote scientific literacy and inspire young people to become explorers in science and research-based technology, especially within groups that have been historically underrepresented in the US 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 Fiscal Years (FY) 2011–2015.

After a period of vigorous community review and discussion, 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.

Detailed planning at the work package level is provided yearly in the NOAO Annual Program Plan.

This is a living document. This plan is updated annually to adapt to changing events, priorities, and actual versus projected funding. In particular, this revision has been heavily influenced by the most recent decadal survey report *New Worlds, New Horizons in Astronomy and Astrophysics* and initial reactions by the National Science Foundation to that report.



Figure 1: The US O/IR System

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

1.2 NOAO and the US Ground-Based O/IR System

The US Ground-Based Optical/Infrared (O/IR) System is a network of observatories dedicated to excellence in scientific research, education, and public outreach. The System enables experimentation and exploration of the observable Universe for all US scientists. Funding for the construction and operation of these observatories has come from federal and state agencies as well as generous donations from private individuals and foundations.

The original concept for an O/IR System emerged from the 2001 decadal survey and has steadily gained acceptance in the broader community since then. This acceptance has been driven by the success of the NSF-funded Telescope System Instrumentation Program (TSIP), closer coordination and engagement between NOAO and a wide range of other US-led observatories, an increased number of open-access nights on non-federal facilities, and the broadening recognition that increased international competition in ground-based astronomy requires a more coordinated response across all US facilities to maintain US leadership.

The NSF 2006 Senior Review and 2010 decadal survey reports further endorsed the System concept.

Further development of the O/IR System rests on two key strategies. First is the continued use of federal money (from NSF and other agencies) 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. Providing increased access to the broad US community will strengthen that community and allow it to compete scientifically at the highest level in the international arena. Second, given that the System is the sum of *all* extant American facilities, NOAO will facilitate a discussion among *all* interested System stakeholders to develop a viable roadmap that will guide coherent and coordinated allocation of available resources across *all* System facilities. A successful System roadmap with broad endorsement benefits all US astronomers, whether particular resources go to federal or non-federal facilities, by increasing the breadth of available world-class scientific capabilities. In other words, a “win” for an individual facility is a “win” for all US ground-based astronomy, whether or not that new capability is available to everyone all the time.

NOAO operates facilities that form the open-access backbone of the US O/IR System. In addition, NOAO provides the leadership necessary to develop the System for the benefit of *all* American astronomy and to facilitate open access via peer review to all System facilities. In combination, these related activities help the US community to meet successfully the rising challenge for leadership from other international communities.¹

Today, NSF invests about \$60M in the US O/IR System through NOAO, Gemini, Telescope System Instrumentation Program (TSIP), and a variety of other programs, e.g., Large Synoptic Survey Telescope (LSST) and Giant Segmented Mirror Telescope (GSMT) design and development and Sloan-III research programs. That investment provides a rich harvest in terms of highly cited breakthrough papers (e.g., the accelerating universe), number of papers published, number of early career scientists supported, and leveling the playing field for all qualified researchers through open access. An increased emphasis on large, rich, survey data sets in the years ahead can only improve that return-on-investment.

1.3 NOAO at the Science Frontiers of the 2010 Decadal Survey

The Astro2010 decadal survey report *New Worlds, New Horizons in Astronomy and Astrophysics* (NWNH), released in mid-August 2010, presents challenges and opportunities for NOAO over the period covered by this LRP. Converting those potentialities into realities will depend in large part on funding actions made by the NSF Astronomical Sciences (AST) division. In turn, those actions will be driven by NSF programmatic priorities and discussions with the broader research community. A vital NOAO role in these deliberations is to deliver to NSF and the research community a strong LRP that offers a focused, efficient, and cost-effective response to the NWNH recommendations for ground-based science.

Over the next five years (and beyond), NOAO and the research community it serves will have major leadership roles providing, operating, and utilizing unique facilities for the three NWNH Science Objectives: Cosmic Dawn, New Worlds, and Physics of the Universe. These facility concepts and designs are the result of decade-long planning and optimization. Specific areas of leadership include the following:

¹ For a complete overview of the US O/IR System concept and status, see: www8.nationalacademies.org/astro2010/DetailFileDisplay.aspx?id=437.

- **Characterization of dark energy and dark matter in the early universe** will define accurately the development of structure—the essential precursor to formation of galaxies and all that they contain.² Three major new NOAO surveys, the Dark Energy Survey (DES) at the Blanco 4-m (2012–2017), the Big Baryon Oscillation Spectroscopic Survey (BigBOSS) at the Mayall 4-m (2017–2021), and the Large Synoptic Survey Telescope (LSST) (2019–2028), will provide the community with the essential data foreseen in NWNH and other national planning reviews.³
- **Exploration and characterization of the time-domain** will detect the vast majority of asteroids potentially hazardous to life on Earth, map galactic evolution in the structure of the Milky Way, and provide urgently needed statistics on supernovae, including especially the rarest. NOAO facilities already are used heavily for follow-up observations of time-variable objects found by other facilities, e.g., Swift, Palomar Transit Factory, and Catalina Sky Survey. The DES and (dramatically) LSST will each increase the number of transient triggers and the pressure for follow-up support, which may be facilitated in the future by a closer relationship with Gemini.
- **Exoplanet characterization and the study of their parent stars** will reveal the composition of exoplanet atmospheres and the extent of their habitable zones. The Gemini Planet Imager (GPI) will become available during this LRP period and will allow scientists to obtain high signal-to-noise spectra of dozens of Jovian-class planets through a combination of key projects and principal investigator-class investigations. Meanwhile, precise determination of the physical properties of hundreds of parent stars identified by NASA Kepler and other missions/surveys will be possible using the new generation of optical (Mayall/KOSMOS, Blanco/COSMOS, Gemini/GHOS) and near-IR (Gemini/FLAMINGOES-2, Blanco/TripleSpec) spectrographs that will be deployed during this LRP period.

This leadership will be enabled by already *established* scientific and technological collaborations with university-based groups (e.g., Ohio State, Cornell, and our WIYN, SOAR, and SMARTS partners, etc.), other US-led observatories (e.g., Gemini, Keck, and other operations of 3- to 10-m-class telescopes), other US national science centers (Fermi National Accelerator Laboratory, Lawrence Berkeley National Laboratory, National Center for Supercomputing Applications, SLAC), major international science collaborations (LSST, DES, BigBOSS), and, especially, our dynamic and world-leading user community.

Finally, experience teaches us a fundamental lesson. **Unknown unknowns**, sudden and unexpected breakthroughs, black swans—impossible to predict, but often the most important—will emerge in the coming decade. Discovery of the ubiquitous presence of dark matter and dark energy are the quintessential illustrations of this lesson. Because such discoveries are unpredictable, NOAO deploys excellent general-purpose instruments and then, through an open telescope allocation process, unleashes creative minds to use those instruments for exploration. A strong national observatory dedicated to open-access research affiliated with other strong US-dominated facilities, such as Gemini, maximizes the likelihood

² NOAO scientists and community scientists have a long history of key discoveries in these areas using NOAO facilities. The discoveries of anomalous galaxy disk rotation (Rubin, Ford, and collaborators) and giant luminous arcs in massive clusters (Lynds and Petrosian) helped establish the ubiquity of dark matter in the universe. During the 1990s, NOAO scientists and facilities played a key role in the initial discovery of the accelerating universe and, hence, the universal presence of dark energy.

³ For example, the Particle Astrophysics Scientific Assessment Group of the DOE High Energy Physics Advisory Panel and the NASA *Beyond Einstein: From Big Bang to Black Holes* reviews.

that the right minds, regardless of who they are or where they work, will connect to the right instruments to make those big leaps forward.

Since the 2005–2006 Senior Review, with NSF support and strong community participation, NOAO has laid a strong foundation for the highest priority NWNH science. Building on that foundation, this LRP brings to fruition DES, BigBOSS, and LSST, while updating the NOAO complement of general-purpose instrumentation and vigorously seeking opportunities for strengthening community access to the System of public and private observatories.

1.4 High-Level Deliverables: Highlights

At the time of this writing (March 2011), NOAO faces significant long-range planning challenges. These challenges are described in detail in sections 6 and 7. For now, NOAO has made certain high-level assumptions: (a) the NOAO base budget will increase annually between 1 and 3%; and (b) the overall NOAO mission and program will not change dramatically during this planning period.

1.4.1 NSF base funding

NSF base funding will enable the following on-going NOAO activities:

- Operation of NOAO facilities on Kitt Peak (Mayall 4-m, 2.1-m) and NOAO obligations to the WIYN 3.5-m facility
- Operation of NOAO facilities on Cerro Tololo (Blanco 4-m) and NOAO obligations to the Southern Astrophysical Research (SOAR) 4.1-m facility on Cerro Pachón
- Facility operations support services for more than 20 tenant observatories (many with more than one telescope or experiment)⁴ on Kitt Peak, Cerro Tololo, and Cerro Pachón on a cost recovery basis governed by federal regulations and directives
- Support services for the scientific users allocated observing time by NOAO at non-NOAO, US System facilities including the Gemini Observatory
- Science data management operations and development services that are focused on immediate NOAO needs, especially in the area of wide-field imaging with Mosaic-1, Mosaic-2, and the NEWFIRM wide-field infrared imager, Dark Energy Camera (DECam), and WIYN One Degree Imager (ODI)
- Education and Public Outreach (EPO) programs that focus on critical, local activities/needs while maintaining a national (global) perspective through innovation
- Technical support, fabrication, and program management required for instrumentation development funded through base and supplementary budget allocations, e.g., Renewing Small Telescopes for Astronomical Research (ReSTAR)
- Community engagement in the Large Synoptic Survey Telescope (LSST), especially in areas of science mission refinement, follow-up campaign requirement definition, and operations requirement definition
- Administrative and facility operations services necessary for an organization with more than 350 employees supporting the operations of more than 30 telescopes at two sites on different continents

⁴ For reference, the NOAO tenant observatories are listed in section 8.

NSF base funding will also enable the following finite duration activities:

- Delivery of a ground-layer adaptive optics system with a high spatial-resolution imager for the SOAR 4.1-m telescope
- Design and development activity for LSST including telescope systems and on-site support facilities
- Tucson base facility renovation to consolidate certain existing groups and accommodate LSST Telescope & Site construction team
- Preparation for the delivery and operation of the Dark Energy Camera (DECam) at the Blanco 4-m telescope on Cerro Tololo and the associated data system for community users, and then operation support per existing agreements
- Development support as needed for the Big Baryon Oscillation Spectroscopic Survey (BigBOSS) project at the Mayall 4-m telescope, including as-yet-to-be-determined modifications to the Mayall
- Completion of WIYN One Degree Imager (ODI) (if WIYN partnership can raise the necessary funding)
- Launch System Roadmap development process
- Prepare material for NSF AST strategic portfolio review (exact deliverables to be defined by NSF AST)
- Prepare material for the cooperative agreement recompetition process (exact deliverables to be defined by AURA and NSF)

As a result of recent decisions by NSF AST, NOAO assumes it will **not** support the following activities during this period:

- Community engagement in the Giant Magellan Telescope (GMT), and Thirty Meter Telescope (TMT) development projects—no such activity can be defined until the NSF announces its strategy for federal investment in a large aperture telescope program
- Program management services for an NSF Giant Segmented Mirror Telescope (GSMT) program—NSF AST has assumed direct responsibility for any such program
- Program management services for the NSF Telescope System Instrumentation Program (TSIP) after FY 2011—NSF AST has decided to end (or at least suspend) TSIP from FY 2012 forward

1.4.2 NSF supplementary funding

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

- Major deferred maintenance catch-up and infrastructure improvement program (American Recovery and Reinvestment Act of 2009, ARRA, funded)
- Additional participation in LSST design and development phase beyond what is possible with base funding only

- Annual Research Experiences for Undergraduates (REU) programs in Tucson and La Serena (as funding permits)
- Community access to the Palomar Observatory Hale 200-inch telescope (ReSTAR Phase 1; funded in FY 2009 for three years, with an option for two more years if additional funding is available)
- New, medium-resolution, optical spectrograph (KOSMOS) for Mayall telescope (ReSTAR Phase 1, funded in FY 2009, first light in first quarter of FY 2012)
- New, medium-resolution, optical spectrograph (COSMOS) for Blanco telescope (ReSTAR Phase 1, funded in FY 2010, first light in third quarter of FY 2012)
- New, medium-resolution, near-IR spectrograph (TripleSpec) for Blanco telescope (ReSTAR Phase 1, funded in FY 2010, planned delivery date FY 2014)
- Continued funding for instrumentation development at 6- to 10-m facilities within the System in return for community access (TSIP, FY 2011 only)
- New 2- to 4-m telescope instrument, capability, and infrastructure development through ReSTAR phase 2 (*not yet funded*)
- New, high-resolution, optical spectrometer for Gemini (*not yet funded*)
- Tucson base facility expansion (*not yet funded*)
- Act as Lead Organization for LSST Telescope & Site construction work package (*not yet funded*)
- La Serena base facility expansion to accommodate LSST operations (using LSST construction funding) (*not yet funded*)
- New, high-speed, data network link between La Serena and Cerro Pachón and a new data facility in La Serena to support both LSST and other local tenant data transfer and computing needs (using LSST construction funding) (*not yet funded*)
- Participation in GMT and/or TMT projects as requested and funded by NSF (*not yet funded*)

1.5 NOAO Strategic Vision: Background Documents

For easy reference, this subsection 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

ReSTAR documents: committee reports, Phase 1 implementation, Phase 2 planning

www.noao.edu/system/restar

ALTAIR committee, final report

www.noao.edu/system/altair

AURA Future of NOAO committee, white paper

www.noao.edu/system/future09

NOAO Long-Range Plan 2011

AURA Decadal Survey committee, final report

www.aura-astronomy.org/nv/Astro2010PanelDocs/Science%20for%20the%20DSC%20Report_V4_7.pdf

NOAO & the Ground-based O/IR System: A White Paper for the 2010 Decadal Survey

www8.nationalacademies.org/astro2010/DetailFileDisplay.aspx?id=437

New Worlds, New Horizons in Astronomy and Astrophysics

http://www.nap.edu/catalog.php?record_id=12951

2 High-Level LRP Development Framework

2.1 Strategic Principles

Current NOAO strategic principles can be extracted from the reports of four key committees:

- NSF Senior Review of MPS-AST Facilities
- ReSTAR (Renewing Small Telescopes for Astronomical Research)
- ALTAIR (Access to Large Telescopes for Astronomical Instruction and Research)
- 2010 Decadal Survey

These principles are:

1. In partnership with other private and public observatories, enable a US system of ground-based facilities that spans the 2- to 10-m range of telescope aperture sizes, includes a balanced suite of scientific capabilities, and provides open access via peer review to a broad range 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.
2. Enhance the US system through participation in the development of new major facilities such as LSST. 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.
3. 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.”⁵
4. As opportunities arise, leverage NSF investment by using funding from other federal agencies (e.g., DOE, NASA), state governments (e.g., WIYN, SOAR university-based partners), and/or private sources to enable high-impact science capabilities and/or projects.⁶

In practical terms, Principle 1 implies that the operation and maintenance of NOAO facilities on Kitt Peak, Cerro Tololo, and Cerro Pachón as well as the development and deployment of new scientific capabilities at those facilities remains the highest priority for the allocation of *base funding* from NSF during the period covered by this LRP (see section 7).

As *supplementary funding* from NSF or other agencies allows, the next practical priority is gaining access to science capabilities desired by the community-at-large through partnerships for access to existing capabilities and/or development of new capabilities on existing 3- to 10-m class telescopes.

In response to Principles 2 and 4, NOAO plans to use a combination of base and supplementary funding to continue significant involvement in the LSST Project. The engineering and technical experience gained through NOAO involvement enables future NOAO partici-

⁵ From Executive Summary, Broadening Participation at the National Science Foundation: A Framework for Action, August 2008.

⁶ A recent example is the Dark Energy Survey (DES)/Dark Energy Camera (DECam) project funded primarily by the Department of Energy (DOE). See www.darkenergysurvey.org/.

pation in major instrumentation or facility development projects, following a forward-looking research and development strategy developed over decades.

With encouragement from various community-based oversight committees, NOAO desires strongly to re-engage with the Giant Magellan Telescope (GMT) and/or Thirty Meter Telescope (TMT) projects during their construction and operations phases. Without such re-engagement, a large part of the US community will likely have no access to these new, revolutionary facilities, to the general detriment of US astronomy. The nature and extent of such re-engagement is an issue of active discussion within NSF AST. Unfortunately, at this time, it is unclear whether such re-engagement can or will occur during this planning period.

2.2 High-Level Planning Assumptions

For the planning period FY 2011–2015, NOAO has made the following *conservative* assumptions:

- A Large Science Program (LSP) on the Blanco 4-m telescope will begin during FY 2012. That LSP is the Dark Energy Survey (DES). Later in this LRP period, proposals for a new LSP at the Blanco telescope may be solicited. If so, the solicitation for such proposals will use the LSST follow-up requirements as a primary driver.
- Design and implementation of an LSP on the Mayall 4-m telescope will begin during this planning period, although actual science observing is unlikely to begin until after this planning period. That LSP is the Big Baryon Oscillation Spectroscopic Survey (BigBOSS) project.
- ARRA-funded projects in Tucson and La Serena will be completed during the first 24 months of this period.
- The ReSTAR Phase 1 implementation program will receive no more than \$1M during FY 2011, in addition to the \$6.9M it received in FY 2009–2010.
- A proposal for ReSTAR Phase 2 implementation will request up to \$3M per year in each of FY 2012, FY 2013, and FY 2014. The Phase 2 proposal will be developed with community involvement and submitted to NSF in early FY 2012.
- The current relationship between NOAO and Gemini will continue unchanged. However, NSF will provide supplementary funding to NOAO for the design, development, construction, and delivery of at least one facility-class instrument for Gemini.
- NOAO will continue to have a major role in the design and development phase of the LSST project. Through at least FY 2013, NOAO will remain responsible for telescope and site design and development activities. If construction funding is approved (not likely before FY 2014), the NOAO-based Telescope and Site group will expand as necessary to execute the construction phase of their work packages.
- The number of NOAO staff supported by the base budget will grow by less than 5% during this planning period (approximately 15 or fewer 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 and LSST).

2.3 ReSTAR: Renewing Small Telescopes for Astronomical Research

In partial response to the recommendations of the 2006 Senior Review of NSF AST, 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.⁷

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, scientific, engineering, and technical support) but primarily funded by supplementary NSF grants.

2.3.1 ReSTAR Phase 1 (ReSTAR-1)

In FY 2009, NSF approved the Phase 1 proposal for the first three years of this program and has provided \$6.9M to date. Using these funds, NOAO will:

- Obtain access to nominally 23 nights per year for three years at the Palomar Observatory Hale 200-inch telescope for the community-at-large, in particular, for access to existing, medium-resolution optical and near-IR spectrographs. *This agreement has been established.*
- Upgrade the Mosaic-1 wide-field optical imager at the Mayall 4-m telescope with new detectors and detector controllers. *This project was completed during FY 2010.*
- In collaboration with The Ohio State University, deploy medium-resolution optical spectrographs called KOSMOS and COSMOS at the Mayall and Blanco 4-m telescopes, respectively. *This project has reached the fabrication and lab-integration phase.*
- In collaboration with Cornell University, deploy a medium-resolution near-IR spectrometer known as TripleSpec at the Blanco 4-m telescope. *This project will start in FY 2011 and be completed by FY 2014.*
- Upgrade the Blanco Hydra/Bench spectrograph detector and detector controller. *This project will be completed during FY 2012.*

During FY 2011, NOAO will request ReSTAR-1 funding to extend for two years the Caltech-NOAO agreement for access to the Palomar Observatory 200-inch Hale Telescope.

2.3.2 ReSTAR Phase 2 (ReSTAR-2)

During 2010, NOAO reconvened the ReSTAR committee. The committee was asked to review progress on addressing their original recommendations and to prioritize activities for a phase 2 proposal (also known as ReSTAR-2). They also were asked to recommend a process for community engagement in carrying out the ReSTAR activities. The ReSTAR committee proposed an open solicitation and selection process that NOAO is now executing.

In November 2010, NOAO held an open invitation informational meeting with prospective partners to discuss the ReSTAR-2 solicitation proposals, the partnership selection

⁷ The ReSTAR final report is available online from www.noao.edu/system/restar.

process, and how the funding proposal for the NSF would be created. A formal open solicitation for proposals was released shortly after this meeting.

In February 2011, NOAO accepted proposals for partnerships in the following areas: infrastructure improvement, new instrumental and observing capabilities, increased access, and studies for future activities. These proposals covered activities at both NOAO and non-NOAO facilities. A review team consisting of NOAO and non-NOAO personnel evaluated these proposals and made recommendations to the NOAO director.

During FY 2011, NOAO will form partnerships and submit a funding proposal to NSF. In general terms, NOAO expects to request approximately \$10M over three years.

Funded ReSTAR-2 projects will be folded into NOAO long-range planning during FY 2012. At this time, NOAO expects that most ReSTAR-2 activity will occur within non-NOAO groups or at non-NOAO facilities. If so, folding in ReSTAR-2 activity will have little impact on the overall program of NOAO, while providing significant new scientific capability to the US System.

2.4 ALTAIR: Access to Large Telescopes for Astronomical Instruction and Research

In addition to the ReSTAR committee, NOAO organized a second external committee to review current and future capabilities across the US O/IR System for facilities with apertures greater than 6 m. The ALTAIR committee also surveyed the entire community and distilled a wide range of input. In their report, they provided four key recommendations:⁸

Develop the Large Telescope System. The committee recommended, "...NOAO take the lead in working with the US community to establish mechanisms for planning together the development of the entire U.S. system of large telescopes. Fundamental to this recommendation is that NOAO establish and maintain a transparent roadmap for the development of the large telescope system based on regular input from the US community, and that NOAO be an active advocate for the development of the large telescope system, using tools such as TSIP funding, input to the Gemini Board, and other methods (e.g., time purchases and trades) to achieve a balance of open access capabilities that is aligned with the research goals of the US community." NOAO will form a community-based committee during FY 2011 to create such a roadmap.

Increase funding for the Telescope System Instrumentation Program. The committee recommended that NSF increase TSIP funding to \$10M per year. NOAO, among others, advocated for this level of funding during the 2010 Decadal Survey committee deliberations. Unfortunately, the 2010 Decadal Survey committee report recommended a cap of \$5M per year; moreover, NSF has suspended TSIP indefinitely starting in FY 2012 in order to fund other programs (such as the Mid-Scale Initiatives Program recommended by the decadal survey).

Increase the alignment between Gemini and the US community. In particular, the committee desired that NSF consult with NOAO and the community-at-large to seek ways to more effectively influence Gemini governance and strategic decisions so that Gemini opera-

⁸ The ALTAIR final report is available online from www.noao.edu/system/altair.

tions and instrumentation evolved to better match US community needs and expectations. The NSF is actively consulting with its international partners in this matter.⁹

Consider a larger share in Gemini in the post-2012 partnership. The committee supported the acquisition of a larger Gemini share but only under the condition that “...*Gemini becomes more responsive to the US community and evolves to a suite of instrumentation, operations modes, and other services that are well aligned with the needs of the US community.*” US share is expected to grow from 50% to somewhere in the range of 65% to 80%. The decadal survey recommended that NSF invest an additional \$2M per year for this purpose. Such additional funding has not yet materialized.

NOAO can only directly respond to the first recommendation but remains in constant discussion with NSF, AURA, and various community-based committees about the implementation of the other three recommendations.

2.5 Partnerships with Emerging International Astronomy Communities

The international astronomical landscape is changing. The US and Europe will see significant new challenges for scientific leadership in the years ahead from countries such as Brazil, India, Japan, People’s Republic of China (PRC), Republic of Korea (ROK), and Russian Federation. For example:

- ROK and Australia have joined the GMT project as full partners.
- Japan has joined the TMT project as a Collaborating Institution with the expressed desire of eventually becoming a full partner. Japan has made significant scientific, technical, and financial contributions to the Atacama Large Millimeter Array already.
- PRC and India have joined the TMT project as Observers.
- Brazil has announced it will join the European Southern Observatory (ESO), subject to final approval by the Brazilian Congress.
- Canada and Australia are discussing whether or not to join the ESO.

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 the talent pool of Brazil 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.

⁹ The 2010 decadal survey recommended that NSF “...should consider consolidating the National Optical Astronomy Observatory and Gemini under a single operational structure, both to maximize cost-effectiveness and to be more responsive to the needs of the U.S. astronomical community.” As mentioned above, this LRP revision expressly ignores that possibility.

2.6 NOAO and Official National Priorities

In August 2009, the Offices of Management and Budget (OMB) and Science and Technology Policy (OSTP) directed all federal agencies to explain how their science and technology funding plans for FY 2011 addressed four “practical challenges,” strengthened four “cross-cutting areas” that enabled successful answers to the practical challenges, enabled agency-funded scientists to thrive in an “open innovation model,” and measured success so that scarce resources could be used most effectively.¹⁰ OMB and OSTP provided similar direction in July 2010 in advance of the preparation of the FY 2012 federal budget request.¹¹

While NOAO cannot address all the challenges posed in this memo (e.g., enabling healthier Americans through biomedical science and technology development), the NOAO long-range program does respond in many areas, including:

Increasing productivity of American research institutions. NOAO was founded on the principle that open access through peer review to world-class facilities was crucial for the advancement of US astronomy and astrophysics. For more than 50 years, the national observatory has provided the research facilities and tools necessary for men and women of all backgrounds from institutions both small and large to explore the physical universe. On the way, these pioneers have identified and characterized such previously unknown phenomena as dark matter and dark energy. Open access by peer review makes NOAO the natural platform for early-career researchers based at institutions throughout the US to try new ideas and solidify their careers. An important complementary mission is to operate and maintain NSF-funded infrastructure on remote mountains in Arizona and Chile to allow university-based groups to deploy their own astronomical experiments. Without that infrastructure, many groups would be unable to proceed. Currently, NOAO is supporting more than 30 such groups from major research universities e.g., University of North Carolina to smaller universities e.g., East Tennessee State University (a member of the SARA Collaboration).

Strengthening STEM education at all levels. Astronomy has tremendous impact in the classroom and in the popular press and, therefore, represents one of the most dramatic and accessible public views into scientific research and federal funding for research. NOAO raises the level of those views by ensuring that the teachers of astronomy at every level can be active researchers, participating in the latest discoveries, and communicating that excitement to students. NOAO has created and led several nationally recognized K-12 hands-on science discovery programs. Undergraduate students participate in the long-running NOAO summer research and engineering experience programs, working with staff scientists on research problems that often lead to world-class results and publications. Other undergraduate students use NOAO facilities under the tutelage of their undergraduate advisors. Graduate students and early-career post-graduate researchers use facilities and tools enabled by NOAO to solidify their research careers and establish their credentials so they can advance in their careers. Undergraduate- and graduate-level astronomy and engineering students often participate in the design and construction of focal plane instrumentation used on NOAO telescopes. NOAO also provides opportunities to local college and university students in technical disciplines through part-time internships or research assistantships; these students gain professional experience

¹⁰ Orszag and Holdren, Science and Technology Priorities for the FY 2011 Budget, White House memo M-09-27, 4 August 2009.

¹¹ Orszag and Holdren, Science and Technology Priorities for the FY 2012 Budget, White House memo M-10-30, 21 July 2010.

while contributing to the success of NOAO development projects. NOAO helped found the Large Synoptic Survey Telescope (LSST) Project that will produce a massive database accessible to educators at all levels, enabling cosmic inspiration, exploration, and education for students of all ages.

Improving our information infrastructure. Peta-scale computing and massive database mining are cornerstone technologies under development right now in the public and private sectors. Developing the information technology required to make LSST a success involves federal laboratories (such as NOAO, NCSA, and SLAC) as well as private sector companies (such as Google, Microsoft, Amazon, and eBay). By supporting the development of LSST with its fellow LSST partners, NOAO enables a rich, new, research opportunity for information technology, computer science, and astronomy. In turn, this research will contribute to continued expansion of the information technology sector that underpins a large fraction of the American economy today.

Measuring success. NOAO functions within a rich and diverse oversight environment that provides regular feedback from active researchers and/or managers appointed to several committees by federal funding agencies, AURA, and the NOAO director. This oversight environment is supported by a robust set of success metrics (e.g., numbers and citation rates of scientific publications produced using NOAO facilities, technical downtime of NOAO facilities, user demand for access to NOAO facilities). In addition, NOAO periodically commissions surveys of its user community to get direct input on ways NOAO can make its programs more effective. Careful monitoring of these inputs helps NOAO invest its resources wisely.

Taking advantage of the open innovation model. Today's research environment is highly distributed. Labs must be "...highly open to ideas from many players, at all stages,"¹² must work collaboratively, and must remain skilled in the practicalities of "...turning ideas into realities."¹³ Over the last 25 years, NOAO has thrived by embracing these principles through collaborative incubation, development, and/or construction of major new facilities (e.g., WIYN, SOAR, Gemini, TMT, LSST), capabilities (e.g., Dark Energy Camera, One Degree Imager, NEWFIRM), and organizational paradigms to advance the US astronomy research enterprise (e.g., management of TSIP, which underlies the ongoing development of the US O/IR System). NOAO will continue to collaborate with public and private universities of all sizes and non-federally funded astronomical observatories as well as federal research centers funded by DOE, NASA, and NSF. Yet the high-level goal remains constant—to make world-class research capabilities available to all qualified researchers through open access peer review, regardless of who they are or where they live.

In short, the NOAO program is a good match to current federal science and technology priorities as established by the Obama Administration, especially through innovation in information technology development, enhancement of research institution productivity, and helping to strengthen STEM education at all levels.

¹² White House Memorandum for the Heads of Executive Departments and Agencies, M-09-27, "Science and Technology Priorities for the FY 2011 Budget," P.R. Orszag, J. P. Holdren, August 4, 2009, Washington, D.C.

¹³ *Ibid.*

3 Top-Level NOAO Organization

The top-level NOAO organization chart is shown in the next figure.

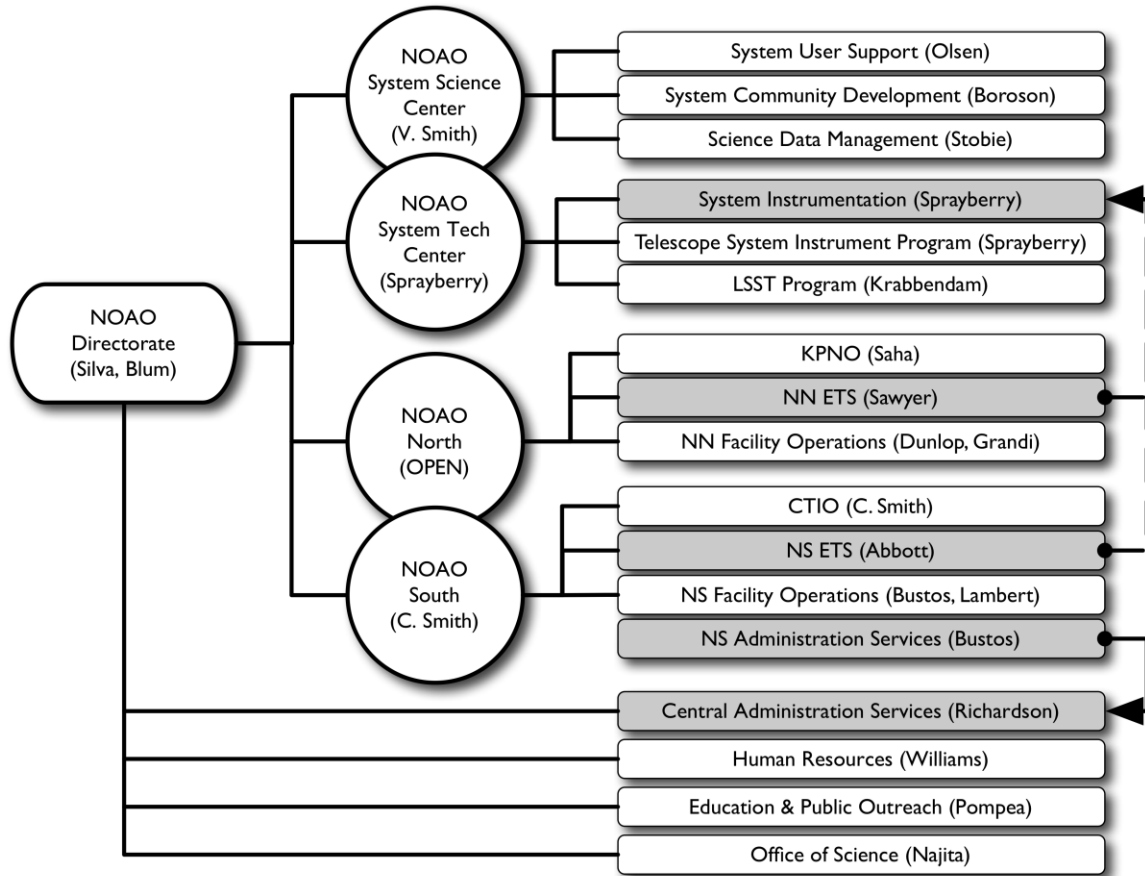


Figure 2: NOAO top-level organization chart

Circles are top-level programs. Boxes are major subactivities. Activity managers are shown in parentheses. At this time, NOAO North does not have a permanent head. Silva and Blum share those duties. NOAO South Administration reports to Central Administration Services (solid arrow, shaded boxes indicate linked activities). NOAO North Engineering and Technical Services (NN ETS) and NOAO South Engineering and Technical Services (NS ETS) provide resources for instrumentation and technology development activity within System Instrumentation (dashed arrows, shaded boxes indicate linked activities).

4 NOAO Divisions

4.1 NOAO North

4.1.1 Overview

NOAO has responsibility for the scientific and technical operations of several major facilities located in or near Tucson, Arizona, including the Kitt Peak National Observatory and the downtown physical plant occupied by several units of NOAO and the National Solar Observatory (NSO) as well as various associated project and operations teams such as ATST, LSST, and WIYN. The NOAO director is the *de facto* NOAO North director, but day-to-day operational authority and responsibility is delegated to the NOAO deputy director, associate director for KPNO, and other senior managers.

4.1.2 Kitt Peak National Observatory

4.1.2.1 Overview

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, NSO, the National Radio Astronomy Observatory (NRAO), and over 40 universities and university groups.

Figure 3: Kitt Peak

An aerial view of Kitt Peak with the Mayall 4-m telescope in the foreground.



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 far infrared (e.g., Fermi, GALEX, CXO, HST, Spitzer, Herschel). This effort has led to the deployment of Mosaic (Mayall, recently upgraded) and NEWFIRM (Mayall/Blanco). KPNO is also involved in the development of the WIYN One Degree Imager (ODI) in collaboration with its WIYN partners.

As recommended by the ReSTAR committee, 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 KOSMOS, a medium-resolution optical spectrograph, at the Mayall 4-m telescope, ODI commissioning, and preparations for the BigBOSS Large Science Program, funding and NSF approval permitting. With the continued support of the NSF, this program of modernization and new capabilities will enable KPNO to continue providing the community with forefront astronomical research opportunities.

4.1.2.2 Major activities

KPNO currently operates two research telescopes (Mayall 4-m and 2.1-m) and collaborates in operating a third telescope (WIYN 3.5-m). The Kitt Peak Visitor Center operates four telescopes used for public outreach and education. KPNO provides the common mountain infrastructure and personnel to support the operation of 22 additional non-NOAO tenant telescopes. These activities are executed through the subdivisions described below.

Director's Office. KPNO is led 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.¹⁴ 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 the KPNO tenant observatories. The KPNO Director's Office also assists the NOAO Director's Office in reporting and planning activities.

Support Office. The KPNO Support Office provides visiting observers to 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 oversight committees and the NSF. Central Facility Operations (CFO), based in Tucson, (see page 22) manages the shuttle and bus service used by staff and visiting observers to travel between Tucson and Kitt Peak.

Mountain Facilities. The Mountain Facilities group maintains common infrastructure for the mountain (e.g., water plant, phone system, roads, 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 NOAO North Engineering and Technical Services, NSO, and WIYN Observatory with projects and major maintenance; and maintains the mountain-based vehicles.

During this LRP period, KPNO is embarking on several major initiatives funded by the American Reinvestment and Recovery Act (ARRA) of 2009. These projects include a major renovation of the water system and a new instrument handling facility. For clarity, and because these ARRA projects closely involve staff in the Central Facilities Operations group in Tucson where additional ARRA activity is being done, these projects are all grouped together in section 4.1.4.6 below.

Mountain Science Operations. Mountain Science Operations includes the scientists and technical support staff who 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; coordinate with the NOAO System Science Center's Science Data Management group about the proper archiving of data obtained as part of NOAO

¹⁴ During FY 2010 and 2011, the NOAO director has temporarily taken over this responsibility as the WIYN partnership grapples with the financial and technical challenges associated with ODI.

science programs undertaken on Kitt Peak; and assist the visiting observers in the planning, execution, and post-observing data reduction for their science programs.

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 in 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 mostly self-supporting—only the KPVC manager is supported by base funding.

4.1.2.3 Major planned deliverables

Major planned deliverables for KPNO in this period include:

- *FY 2011:* Conduct the review process of the BigBOSS proposal (COMPLETED). Work with BigBOSS Collaboration to prepare for Conceptual Design Review and the NSF approval process.
- *FY 2012:* Complete the dining facility and renovation of one dormitory (not yet funded). Commission KOSMOS. Re-install NEWFIRM upon its return from the Blanco 4-m telescope.
- *FY 2013:* Begin ODI science operations at the WIYN 3.5-m (optimistic). Complete renovation and expansion of the KPVC (if funding permits).
- *FY 2014:* Complete renovation of second dormitory (not yet funded), providing adequate housing for visiting astronomers and outreach programs supported by KPVC and KPNO.
- *FY 2015:* Engage in the next round of instrumentation upgrades identified by ReSTAR Phases 2 and/or 3 (TBD).

4.1.2.4 Special topic: BigBOSS

NOAO announced in December of 2009 an opportunity to partner with NOAO and NSF to pursue a Large Science Program with the Kitt Peak Mayall 4-m telescope and to develop a major observing capability for it (www.nao.edu/kpno/largescience.html).

The dual goals of this opportunity were to enable frontier science and to improve the US O/IR System facilities. Although there were no restrictions on the type or scale of instrument, NOAO encouraged proposals that will build on the Mayall telescope's strengths, utilizing its unique wide-field capabilities. In exchange for providing the community with a new observing capability for the Mayall, the NSF and NOAO offered to provide dedicated telescope time on the Mayall for the proposed science program. That offer represents a significant financial contribution—a 500-night allocation on the Mayall is equivalent to about \$7M in operations costs.

The use of the new capability will be available to the general community through the normal process of the NOAO Time Allocation Committee (TAC) during the time the Large Science Program would be carried out and for several years beyond the completion of the proposed project.

As a result of this process, NOAO has tentatively agreed to partner with the Big Baryonic Oscillation Spectroscopic Survey (BigBOSS) Collaboration (PI: David Schlegel, LBNL). Final agreement is contingent on several conditions including satisfactory retirement of scientific and technical risks identified by the proposal review committee during its review process

and approval by NSF to proceed with this multiyear project. Nominally, those conditions would be satisfied by mid-FY 2012 and conclude with an official Memorandum of Understanding among NSF, DOE, NOAO, and LBNL. An optimistic schedule projects that BigBOSS observations would begin in FY 2016 and continue for five years.

4.1.2.5 Anticipated challenges and opportunities

The main challenges facing KPNO during this LRP period are: (1) completing the construction and deployment of ODI on the WIYN 3.5-m telescope; (2) commissioning KOSMOS; (3) moving the BigBOSS project forward; and (4) renewing our experienced but aging staff through new hires to be trained as the next generation of engineers, scientists, and technicians supporting the observatory.

If additional funding could be identified, it would be used to enable more 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, 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.

Maintenance of Kitt Peak as a viable astronomical site requires continued vigilance in regards to light pollution and noise at other electromagnetic frequencies. Commercial pressures for light pollution encroachment are high. Kitt Peak also is seen as a strategic site for communication repeaters for emergency services, law enforcement, and border security. Such installations compromise not just the frequency windows, but also system noise in the instruments. Preserving the observatory as a “quiet” zone from encroaching electromagnetic spectrum noise will pose a challenge, given the competing pressures from other such interests at the observatory site.

There is a growing focus on time-domain science, and Kitt Peak should look to enabling its science operations to participate in community-wide efforts along those lines. In particular, KPNO science operations probably needs to migrate towards an operations model that is nimble enough to respond to increasing volumes of “follow-up” observations of time-critical phenomena, while also proceeding with other projects. Modest investments (perhaps from ReSTAR) can seed such activity through telescope/instrument modifications, and scientific staff interest can drive the development of more flexible operations models.

4.1.3 NOAO North Engineering and Technical Services

4.1.3.1 Overview

NOAO North Engineering and Technical Services (NN ETS) is responsible, with the assistance of Mountain Science Operations and Facilities staffs, for the maintenance and improvement of the telescopes and facility instruments of KPNO and WIYN Observatory. In addition, NN ETS helps maintain the McMath-Pierce and Synoptic Optical Long-Term Investigations of the Sun (SOLIS) telescopes of NSO. NN ETS 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 NOAO and NOAO partner telescopes.

4.1.3.2 Major activities

Site-specific maintenance and support. The NN ETS staff provide expertise in the mechanical, electronic, and software systems in operation on Kitt Peak (including WIYN Observatory and NSO facilities as required/requested) to complement the day-to-day support provided by on-site staff. During this LRP period, the NN ETS staff will support commissioning and operations of at least two new instruments: KOSMOS at Mayall as well as ODI at WIYN provided the WIYN partnership brings that project to a successful conclusion. The group will also be involved in the first years in finishing ARRA projects as well as major repairs to the Mayall and WIYN enclosures, necessary to repair damage caused by recent, severe, winter events.

Instrumentation and technology development. NN ETS staff also work in support of the NOAO System Technology Center (NSTC, described in section 4.4) to develop, build, and deploy new instrumentation. Major activities during this LRP period include: (1) planning and initial implementation of Mayall upgrades related to BigBOSS, and (2) final integration and testing of ODI. Additional instrument development activities are described in the NSTC section.

4.1.3.3 Major planned deliverables

Major planned deliverables for NN ETS in this period include:

- *FY 2011:* Deploy updated controllers and detectors for the Mosaic-1 wide-field optical imager at the Mayall 4-m. [Completed.]
- *FY 2012:* Support commissioning of KOSMOS and development of BigBOSS. Initiate steps to improve the delivered image quality at the Mayall 4-m telescope, including relocation of the observing area to the utility floor (U floor level) in order to minimize thermal sources on the observing floor and telescope environment.
- *FY 2013:* No specific activity planned at this time (see NSTC section).
- *FY 2014:* Complete renovation of the Mayall 4-m telescope dome. Begin any necessary modifications to the Mayall 4-m telescope required to support BigBOSS.
- *FY 2015:* No specific activity planned at this time (see NSTC section).

4.1.3.4 Anticipated challenges and opportunities

The challenges for this LRP period will be to complete the development of TORRENT, ramp up production on ten systems needed to fulfill the obligations of known instruments (COSMOS, KOSMOS, Hydra Upgrade, CHIRON, Mosaic 1.1), and integrating/optimizing these CCD systems. In addition to maintenance engineering at the telescopes, the NN ETS staff will also be engaged in the commissioning of KOSMOS, the recommissioning of NEWFIRM, and exploratory studies for the deployment of BigBOSS on the Mayall. At the same time, many of the same NN ETS staff will be required to support ODI efforts to evaluate the ODI Dewar performance and Orthogonal Transfer Array detectors. Should WIYN secure funding to complete the ODI instrument during this LRP period, additional personnel will be hired to move the ODI project forward.

4.1.4 NOAO North Facility Operations

4.1.4.1 Overview

The primary function of NOAO North Facility Operations is to provide support for NOAO North in Tucson and additional support to Kitt Peak. This support includes providing facility

maintenance and support services to all of the occupants of the Tucson facilities, including NSO, ATST, WIYN, and LSST Corporation (LSSTC). Funding for this support is provided through a recharge indirect-rate revenue process for non-NOAO institutions and consortia.

4.1.4.2 Major activities

Central Facilities Operations. 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
- Voice and video telecommunication systems support/development
- Janitorial and security services
- Parking
- Property management
- Facilities compliance reporting
- Tucson facilities safety and security
- Development and execution of recycling program for all NOAO facilities in Arizona

In Tucson, the main buildings house several programs including NOAO. The nighttime astronomy community includes NOAO headquarters, WIYN, and the LSST Project, as well as space leased to external organizations (e.g., LBT, TMT). The solar community includes the NSO headquarters, GONG, SOLIS, and ATST.

The federal Energy Policy Act and recent Executive Orders for federal facilities may require CFO to implement significant changes to its facilities to comply with new guidelines and regulations during this LRP period. CFO will look to NSF for guidance on any new requirements for existing facilities.

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

On Kitt Peak, CIS helps to support the network infrastructure; computer support is the responsibility of the individual NOAO and NSO units and of other institutions. While the primary function of CIS is to provide computer infrastructure support to Tucson headquarters, support also is given to NSO, ATST, LSSTC, and WIYN. Revenue is generated through direct and indirect support to centers other than NOAO.

CIS cooperates closely with its counterpart organization at NOAO South to maintain common standards and procedures. In addition, the two organizations maintain the network technology that ties the two halves of NOAO together through email, Voice over Internet Protocol (VoIP) telephone service, 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 NOAO, 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.

4.1.4.3 Major planned deliverables

Major planned deliverables for NN Facility Operations in this period include:

- *FY 2011:* Complete installation of new chiller unit for main building. Complete Tucson computer lab upgrade. Upgrade the NOAO-Tucson Web server for speed, capacity, and reliability. Upgrade data links between Admin and Domes on Kitt Peak from 100 Mbps to 1 Gbps. Upgrade link between Kitt Peak and Tucson from 50 Mbps to 250 Mbps. Initiate the Kitt Peak water system renovation and mountain instrument integration lab projects.
- *FY 2012:* Complete the energy management project. Complete the Tucson electrical distribution project. Complete upgrade of “backbone” links in the Tucson network to 10 Gbps. Complete the KPNO water system renovation and mountain instrument integration lab projects.
- *FY 2013:* In cooperation with the University of Arizona, increase the bandwidth from NOAO-Tucson to the scientific Internet from 1 Gbps to 10 Gbps. Upgrade the NOAO-Tucson email server for speed, capacity, and reliability. Initiate the east wing upward expansion of two floors for the Tucson headquarters (if funded).
- *FY 2014:* Begin upgrade of Tucson network by procuring a new backbone switch and initiating upgrades of backbone links from 10 Gbps to 40 or 100 Gbps.
- *FY 2015:* Complete east wing upward expansion of two floors for the Tucson headquarters (if funded).

4.1.4.4 Special topic: renewal of NOAO-Tucson facility

Over the last 10 years, CFO has worked diligently to reduce utility and operational costs by implementing major projects in the area of roof repairs, HVAC, electrical, and water main upgrades. At the same time, the Tucson facilities are aging, and the balance of use is shifting toward more office space and less lab space as new, major projects involving significant staff increases are initiated. In light of these changes, re-engineering of space is being undertaken frequently to meet the needs of the programs. While addressing immediate needs, this re-engineering of (typically) lab or storage space into offices is not ideal and is often problematic due to the constraints of the original building construction. Fire safety and asbestos removal are common concerns now when changing facility use from one aspect to the other. Computer resources have grown immensely in the same time period, and so, space for data servers and archive support is a growing concern.

CFO already has begun supporting the increase in ATST staff that has resulted from the ATST project start in 2009 when major funding was provided for the construction of the telescope. ATST continues to add staff, and so far, CFO has been accommodating them by converting basement lab space into office space. Furthermore, NOAO sees supporting the

LSST Project as one of its highest priorities. NOAO is the lead for the Telescope and Site group. This activity alone will ramp up with 30 people in Tucson during the construction phase. An additional 20–30 staff in other Tucson-based LSST areas also is likely. An LSST Project hosted entirely at NOAO would be a cost-effective solution if modest funds could be identified for a building expansion on the Tucson NOAO site.

A present unknown, which would impact any decision on space requirements, is whether or not NSO/ATST will relocate en-masse to a new headquarters. AURA has placed a call for proposals to host NSO in a new location. It is expected that a decision will be made in 2011 on a new site.

4.1.4.5 Special topic: renovation/expansion of Tucson downtown facility

In order to understand what it would cost to accommodate the increase in staff as described above, during FY 2010, CFO initiated an architectural assessment of the east wing of the main building with an eye toward developing an upward expansion of two floors. This expansion would allow for project growth (LSST and future projects) as well as providing modern space and a better work environment for NOAO, NSO, and other programs. Once completed, NOAO and other staff would occupy the new east wing leaving the bulk of the main building to be renovated or otherwise available for redevelopment. This east wing expansion will require funds above the expected NOAO base allocation for the LRP.

CFO received three bids for an architectural study. A bid from Tucson-based M3 was chosen, and that study was completed in 2010. The study showed the east wing existing structure is capable of taking an expansion of up to three additional floors. The FY 2010 cost for a three-floor expansion was \$13M and about \$8–9M for a two-floor expansion. Each new floor would add approximately 16,000 square feet total, to be divided into offices, meeting areas, and utility space (e.g., restrooms).

The possibility remains (though not yet developed) for an expansion that is part of a University of Arizona and NOAO combined initiative to develop astronomical office and technical facilities on the current NOAO or other site. The east wing expansion itself would allow for the opportunity to redevelop areas of the main building in collaboration with the university while maintaining current staff in the new space (even if NSO relocated).

4.1.4.6 Special topic: ARRA work at NOAO North

At the end of FY 2009, NOAO was awarded \$5.6M in ARRA funding. Half of this allocation is being expended at NOAO North and half at NOAO South. The North funds will be used to execute several, major maintenance and upgrade projects in Tucson and on Kitt Peak. CFO has been working on all the ARRA projects in Tucson and at Kitt Peak.

Major ARRA projects at NOAO North include:

- Installation of a new CNC machine in the Tucson shop (*complete*)
- Renovation of the Kitt Peak water system (in collaboration with KPNO operations) (*in progress*)
- Construction of a Kitt Peak instrument handling facility (in collaboration with KPNO operations and engineering) (*in progress*)
- Replacement of the Kitt Peak Visitor Center handicapped-accessible elevator (in collaboration with KPVC) (*complete*)
- Upgrades to Tucson facility energy management and control system (*in progress*)

- Replacement of Tucson facility electrical distribution system (*in progress*)
- Renovation of Tucson computer room cooling system (*complete*)

Most stimulus support will be conducted through contracts to outside vendors and/or contractors. All ARRA activities in the North will be managed by CFO and KPNO.

4.1.4.7 Anticipated challenges and opportunities

ARRA funding provides a key opportunity for NOAO to address a number of long-term maintenance and space issues on Kitt Peak and at the Tucson headquarters. The challenge facing CFO is to manage and complete the projects enabled by this funding in a timely and efficient manner.

The long-term viability of the Tucson headquarters remains a serious challenge in this LRP period. A realistic plan for targeted expansion on the existing east wing will be completed at the beginning of the LRP period. This expansion would provide room to accommodate LSST Project staff and allow for modernizing, upgrading, and/or redeveloping the 50-year-old main building. Managing planned growth for LSST and ATST in the meantime will be a challenge. ATST, in particular, may require near-term space outside of current NOAO facilities. The timing for LSST Project growth is not yet known, but it could still occur in 2014. This means an effective expansion requires fast-track planning and execution.

4.2 NOAO South

4.2.1 Overview

The NOAO South 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 hosts more than 15 telescopes and projects (see the list in section 8). The SOAR 4.1-m and Gemini South 8.2-m telescopes are located on neighboring Cerro Pachón where LSST will 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 maintain the infrastructure and support the activities of all of the observatories functioning under the AURA umbrella in Chile, including Gemini and SOAR as well as future projects.



Figure 4: Cerro Tololo

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

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 e.g., NSF-funded projects like PROMPT, NASA-funded programs such as the Space Debris program on the University of Michigan Schmidt telescope, university-funded programs such as the Southeastern Association for Research in Astronomy (SARA) 0.6-m telescope, and private US programs such as the Las Cumbres Observatory Global Telescope Network (LCOGTN). An on-going campaign of infrastructure renewal and modernization will continue as funding permits in order to support ongoing and future activities. During this LRP period, NOAO South will have to support the start of LSST construction and plan for LSST operations.

4.2.2 Cerro Tololo Inter-American Observatory

4.2.2.1 Overview

NOAO South science operations revolve around Cerro Tololo Inter-American Observatory (CTIO). When 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, better spatial resolution, blue-optimized instrumentation on SOAR and more red-optimized, higher spatial resolution instrumentation on Gemini South. The blue-red optimization is broadly driven by the order of wavefront correction provided on a 4-m vs. 8.1-m aperture for atmospheric compensation. During this LRP 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.



Figure 5: Cerro Pachón

Aerial view of Cerro Pachón with Gemini South 8.2-m (foreground) and SOAR 4.1-m (background) telescopes.

4.2.2.2 Major activities

Director’s Office. NOAO South is led by an NOAO associate director, and is managed by a team that 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.

User Support Office. The CTIO User Support Office provides visiting observers to the NOAO users of telescopes on Cerro Tololo and Cerro Pachón with pre- and post-observing run logistics support including assistance with travel, dormitory, and meal arrangements. The User Support Office also coordinates communication between observers and NOAO South technical support staff, ensuring that the desired instrument configurations are prepared for each program. The USO Support Office collects fees, assists with tracking observatory performance, and prepares information for reports to oversight committees and the NSF.

Telescope Operations. This group focuses 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. Telescope Operations provides 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.

Mountain Facilities. The Mountain Facilities group maintains the common infrastructure for both Cerro Tololo and Cerro Pachón, which includes provision of all utilities (e.g., water plant, electricity, phone system, computer network), road maintenance, and bus transport. The group also operates the dining and dormitory facilities on each mountaintop, and provides the emergency response coverage of nurses and paramedics. In addition, Mountain Facilities maintains the observatory buildings, assists in observatory projects and major maintenance, and maintains the mountain vehicles.

Outreach. In coordination with the EPO program based in Tucson and other 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 engineering and administrative internship programs.

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 with training programs for local school teachers and municipal observatory staff. In addition to these educational programs, NOAO South EPO pursues an active public outreach program that provides participation and leadership in public events as well as a public visitor program to the CTIO telescopes on Saturdays.

4.2.2.3 Major planned deliverables

Major planned deliverables for CTIO in this period include:

- *FY 2011:* Complete preparations for Dark Energy Camera (DECam) at the Blanco 4-m telescope and support installation of the camera. Install and commission the SOAR Adaptive-Optics Module (SAM) at SOAR.
- *FY 2012:* Lead DECam commissioning. Begin the Dark Energy Survey (DES) and community science operations of DECam. Commission COSMOS.

- *FY 2013*: Refurbish key Hydra components and optimize operations with an up-graded detector system. If funding permits, pursue image quality improvements on the Blanco 4-m, specifically targeting environmental control systems that will aid in managing thermal loads in the dome.
- *FY 2014*: Commission TripleSpec.
- *FY 2015*: If funding permits and interference with DES can be minimized, begin major Blanco 4-m refurbishment project, including refurbishing dome hardware and other critical infrastructure to ensure continuity of service well into LSST era.

4.2.2.4 Special topic: Dark Energy Survey/Dark Energy Camera

In FY 2011, DECam will arrive and be installed on the telescope, allowing both community and DES operations to begin in FY 2012. The DES is a five-year, joint DOE/NSF project that will not only provide an important step in the understanding of dark energy, but also provide the astronomical community access to high-quality imaging in grizY of a 5000-square-degree area of the Southern Hemisphere. As such, it represents an ideal stepping stone for archival research from the Sloan Digital Sky Survey data to the promise of LSST science. DES will use 30% of the time on the Blanco 4-m telescope between 2012 and 2016. In the remaining 70%, DECam also will be available to the astronomical community as a facility instrument, providing a major, new, survey capability for users. CTIO must support operations of DECam for use by both the community and DES, allowing the survey to move forward efficiently to provide this important new archival resource to the community.

4.2.2.5 Anticipated challenges and opportunities

LSST follow-up support. NOAO South and other US O/IR System facilities in the Southern Hemisphere need to prepare for LSST survey follow-up programs, 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. The science produced by other major, new, survey imaging facilities (e.g., DECam, Pan-STARRS, and ODI) also will lead to increased demand 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 1.0-m telescopes at CTIO. Demand for spectroscopic follow-up at the 4-m-class level will be met partially by the planned ReSTAR spectrographs for the Blanco 4-m: one optical (COSMOS) and one near-IR (TripleSpec) (see section 2.2). Both imaging and spectroscopic follow-up for time-domain astrophysics may require changes to the scheduling and operations of the facilities at NOAO South.

Adding 2-m-class telescopes to LCOGTN. LCOGTN continues to express interest in the future deployment of 2-m-class telescopes on Cerro Tololo and Kitt Peak as enhancements to their 0.4- and 1.0-m network under deployment. A total of five 2-m-class telescopes are planned, each with a common optical imaging spectrometer. Through NOAO, the 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. Funding for the design, development, and construction of such telescopes is not available yet. Nevertheless, NOAO continues to monitor progress of this concept and the possibility of collaboration (at least as a host site).

Ongoing instrument commissioning and staffing. 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 approximately 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.

4.2.3 NOAO South Engineering and Technical Services

4.2.3.1 Overview

NOAO South Engineering and Technical Services (NS ETS) provides 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.

4.2.3.2 Major activities

Site-specific maintenance and support. The NS ETS staff provide expertise in the mechanical, electronic, and software systems in operation on Cerro Tololo (Blanco 4-m and smaller telescopes) and Cerro Pachón (SOAR) to complement the day-to-day support provided by the Telescope Operations staff. During this LRP period, the major site-specific activities include extensive support of DECam, helping to resolve start-up difficulties, and supporting the development and implementation of regular maintenance procedures. The NS ETS staff will also support commissioning and operations of two additional NOAO instruments (COSMOS and TripleSpec) and two SOAR instruments (SIFS and STELES). In addition, the group will develop and build parts needed for repairs to and refurbishment of Blanco and SOAR.

Instrumentation and technology development. NS ETS staff also work in support of the NOAO System Technology Center (NSTC, described in section 4.4) to develop, build, and deploy new instrumentation. The staff will play a leading role in the delivery of the detector systems for both COSMOS and TripleSpec and also will participate in the integration of these systems upon arrival at CTIO. Additional instrument development activities are described in the NSTC section.

4.2.3.3 Major planned deliverables

Major planned deliverables for NS ETS in this period include:

- *FY 2011:* Install DECam on the Blanco 4-m telescope. Complete upgrade of “planet finder” fiber echelle spectrograph at the 1.5-m telescope.
- *FY 2012:* Complete detector systems for COSMOS. Participate in COSMOS commissioning. Complete the upgrade of the Blanco Hydra spectrograph, with a new detector controller (TORRENT) and new red-sensitive CCD. Support installation and commissioning of SIFS on SOAR.
- *FY 2013:* Develop detector systems for TripleSpec and participate in final integration of TripleSpec system. Design and fabricate key components of environmental control system for Blanco 4-m. Continue deployment of new TORRENT instrument controllers on all CTIO telescope systems in order to retire aging Arcon systems (as funding permits).

- *FY 2014*: Participate in TripleSpec commissioning. Support installation and commissioning of STELES on SOAR. Design and develop parts for major refurbishments of 4-m telescope systems.
- *FY 2015*: Participate in the development of next-generation instrumentation plans, including design studies, for the Blanco 4-m in preparation to support LSST scientific mission and community use of LSST data.

4.2.3.4 Anticipated challenges and opportunities

The single largest challenge during the first part of this LRP period will be the integration of DECam into the operations of the Blanco 4-m and, more generally, the overall operations of CTIO. The DECam systems are complex, and several subsystems will require extensive regular maintenance on six-month to one-year timescales. Startup issues and debugging of DECam, COSMOS, and TripleSpec systems will also provide a significant load on the NS ETS staff during this period. Balancing the load of this mountain support with the need for ongoing development, both for telescope upgrades and new instrumentation plans of NSTC will require detailed planning and close attention to contingency management in those plans.

4.2.4 NOAO South Facility Operations

4.2.4.1 Overview

NOAO South manages facility operations for all facilities located on the AURA *recinto* (compound) in La Serena and on the AURA property that encompasses and provides access to Cerro Tololo and Cerro Pachón. More specifically, NOAO South Facility Operations operates and maintains the physical infrastructure shared by all facilities hosted by AURA including roads, support buildings, housing, and miscellaneous other facilities.

4.2.4.2 Major activities

Facility Operations. The Facility Operations 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 Facility Operations group provides shared services such as food, lodging, and transportation. Lodging includes not only operations of mountaintop dormitories for visiting scientists, but also maintenance and operations of longer-term housing for resident scientists in the La Serena AURA compound.

Computer Infrastructure Services. The Computer Infrastructure Services (CIS) 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 the NOAO and tenant telescopes, supporting activities that include observation planning and scheduling, some remote observing, and data delivery to users and the NOAO Archive. The CIS group also manages the recently installed VoIP system, which provides advanced telephone services at low cost to all of NOAO South and other users.

4.2.4.3 Major planned deliverables

The major planned deliverables for NS Facility Operations in this period include:

- *FY 2011:* Complete the third phase of the Cerro Pachón dormitory and dining facilities project. Begin preconstruction activities for LSST, including modification of the mountaintop, using supplemental LSSTC nonfederal funding. Begin dormitory renovation on Cerro Tololo. Complete upgrade of international network backbone from 50 Mbps to 1 Gbps.
- *FY 2012:* Develop the design for renovation of La Serena offices, including the LSST office and computing facilities. Complete the site preparation for LSST construction. Complete dormitory renovation on Cerro Tololo. Complete water system renovation that supports both Cerro Tololo and Cerro Pachón. Complete redesign of network links to Cerro Pachón, including the main microwave link and a shared backup link.
- *FY 2013:* Complete infrastructure preparations for LSST construction, including road preparation and facilities necessary to support construction crews on Cerro Pachón. Complete a simple CTIO visitor center with associated small telescope facility (funding permitting).
- *FY 2014:* Support commencement of construction of the LSST mountaintop facilities. Develop La Serena electrical distribution project in order to support new LSST demands on the AURA facilities in La Serena.
- *FY 2015:* Complete installation of the fiber connection from both mountaintops to La Serena. Begin construction of the combined NOAO/LSST facilities in La Serena. Renegotiate the international network connectivity contract to scale bandwidth from 2.5 Gbps up to 10 Gbps at the start of LSST operations.

4.2.4.4 Special topic: renewal of NOAO South downtown facility

During this LRP period, construction of the LSST facilities will ramp up, first on Cerro Pachón and then in La Serena. The LSST telescope on Cerro Pachón will be largely stand alone. The current proposal is that the LSST offices in La Serena will be integrated with NOAO South facilities on the AURA compound, providing extensive and quality interaction between the existing NOAO South staff and new arrivals working on LSST. Full LSST operations will include roughly 60 staff, some of whom will come from existing NOAO South staff. NOAO South will take advantage of this opportunity to re-engineer the existing space and the new construction by LSST in order to optimize it for the combined needs of NOAO and LSST operations, including office space, lab space, and meeting rooms. The LSST base facility will also include a significant computing center. Current plans involve building a new computing center, probably as a separate building, which will support both LSST and all other NOAO South IT needs. This building will replace the aging computer facility upon which NOAO South currently relies and will provide a platform for the future growth of computing resources required to support all NOAO, LSST, and related operations in Chile, including operational servers as well as archival storage and support.

4.2.4.5 Special topic: ARRA work at NOAO South

At the end of FY 2009, NOAO was awarded \$5.6M in ARRA funding. Half of this allocation is being expended at NOAO North and half at NOAO South

Major ARRA projects at NOAO South include:

- Construction of a new wing on the Cerro Pachón dormitory to provide permanent kitchen and dining facilities for all Cerro Pachón-based operations, including SOAR, Gemini South, and (in the future) LSST
- Repair and renovation of Cerro Tololo dormitories
- Repair and refurbishment of the water pump and storage system that serves both Cerro Tololo and Cerro Pachón
- Construction of an instrument maintenance facility for Blanco 4-m telescope (*completed*)
- Upgrade of Blanco 4-m console and computer room for DECam and other new instrument support
- Repair and upgrade of Blanco 4-m mirror coating chamber
- Upgrade of CTIO uninterruptible power supply system to support new instruments (*completed*)
- Purchase and installation of a backup generator for Cerro Pachón common facilities, including dormitories, new kitchen, etc. (*completed*)
- Repair and refurbishment of Cerro Tololo backup electrical facilities (frequency convertor and backup generator)
- Installation of a new CNC machine in the La Serena instrument shop (*completed*)
- Renewal of NOAO South fleet vehicles (*completed*)

Most of the larger stimulus projects (construction and major renovation) will be conducted through contracts to outside vendors and/or contractors. Some of the more technical work on Blanco facilities (e.g., instrument maintenance facility, upgrade of mirror coating chamber) involves purchase of major systems from outside vendors with installation and integration done by local staff with expertise in those systems.

4.2.4.6 Anticipated challenges and opportunities

LSST support is the main challenge anticipated by NOAO South Facility Operations. As the LSST 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.

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 2011. 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.

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 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.

4.2.5 NOAO South Administration

4.2.5.1 Overview

Within a legal and contractual framework established by AURA through its Chilean juridical entity the AURA Observatory (AURA-O), NOAO South Administration provides to NOAO, Gemini, SOAR, and other tenant observatories a range of business services such as accounting, procurement, payroll management, and human resources management. The group must comply with rules and regulations from both the US federal government and the government of the Republic of Chile.

NOAO South, acting on AURA's behalf, executes all local legal and logistical activities required for the preparation for and operation of LSST. The NOAO South Administration and Facility Operations 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.

4.2.5.2 Major activities

Accounting. The Accounting group is responsible for budgets, accounting, and billing for services provided by the NOAO South Facility Operations and Administration groups. Budget preparation and management for the administration and facilities services must be performed in such a way as to allow transparent review of site and per-use fees, which must be approved by the NSF together with overhead rates. In order to manage the risk of exchange-rate variations, the fees are maintained in Chilean pesos, requiring the accounting group to carefully manage transfers between pesos and US dollars for NOAO and all of the AURA programs.

Procurement. The Procurement group is responsible for purchasing, asset control, and warehouse operations, including shipping/receiving. Purchasing within Chile for all AURA programs is managed through this group, which operates under Chilean contract and purchasing regulations. Although the individual AURA programs maintain their own asset registers, the NOAO group maintains the global AURA asset control in order to comply with Chilean regulations and support import/export needs. The warehouse provides a single point of contact for shipping and receiving within Chile and works closely with the AURA Santiago office to manage the international import/export needs of all AURA programs, including shipments of expensive astronomical instrumentation.

Personnel & Payroll. Through its local juridical entity AURA-O, AURA maintains a framework of personnel policies and procedures that are compliant with Chilean labor laws. The overall compensation package for all AURA employees hired within Chile is established through a collective bargaining process repeated every two years.

Based on that framework and the active collective bargaining agreement, the NOAO South Personnel & Payroll group manages the personnel contracts and payroll for all Chilean-national AURA staff working in Chile. This encompasses all Chilean employees of NOAO, Gemini, and SOAR. One-on-one personnel management (i.e., performance evaluations, work assignments) remains the responsibility of each individual program.

4.2.5.3 Major planned deliverables

The major planned deliverables for NS Administration in this period include:

- *FY 2011:* Review all AURA program and tenant agreements. Implement Service Level Agreements with tenants. Transition to new financial and reporting software led by

NOAO Central Administrative Services (CAS) in Tucson, implementing local enhancements to support peso currency and local needs.

- *FY 2012*: Support NSF Business Systems Review.
- *FY 2013*: Support the development of the new NOAO cooperative agreement proposal. Support the increase in LSST activities in Chile, including initial growth in staff, procurement contracts, and extensive international shipping needs.
- *FY 2014*: Support full-scale LSST construction activities, including all Chile-based staffing, accounting, and procurement contracts.
- *FY 2015*: No specific activities planned yet.

4.2.5.4 Anticipated challenges and opportunities

The NOAO South Administration challenges center on the complexity of maintaining regulatory compliance with both US and Chilean entities. Standard NOAO systems developed by CAS in Tucson must be adapted to conform to local needs, which include handling Chilean peso and currency conversions and producing the reports needed by Chilean authorities. And, the systems must be adapted to run concurrently at multiple sites, allowing for connectivity failures, remote mirrors and/or backups, and other standard multisite features.

4.3 NOAO System Science Center

4.3.1 Overview

The NOAO System Science Center (NSSC) is responsible for connecting the community-at-large to the present and future science capabilities of the System. NSSC provides user support for a broad range of observational assets, not the least of which is Gemini. Indeed, NSSC acts as the National Gemini Office for the United States. NSSC is also responsible for NOAO data management development and operations. NOAO staff scientists assigned to NSSC routinely move between supporting current facilities, engaging the community with new facilities under development, and participating in the definition and validation of data products delivered by NOAO.

NSSC provides the following services:

- Support users with observing proposal preparation and submission for all of the System facilities as well as post-observing data processing¹⁵
- Assist non-NOAO System 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
- Develop and operate data management systems and tools, including core IRAF
- Manage the NOAO time allocation process

¹⁵ 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 few years.

NSSC divides its operational duties into four functional units: System User Support, System Community Development, Science Data Management, and the TAC Team.

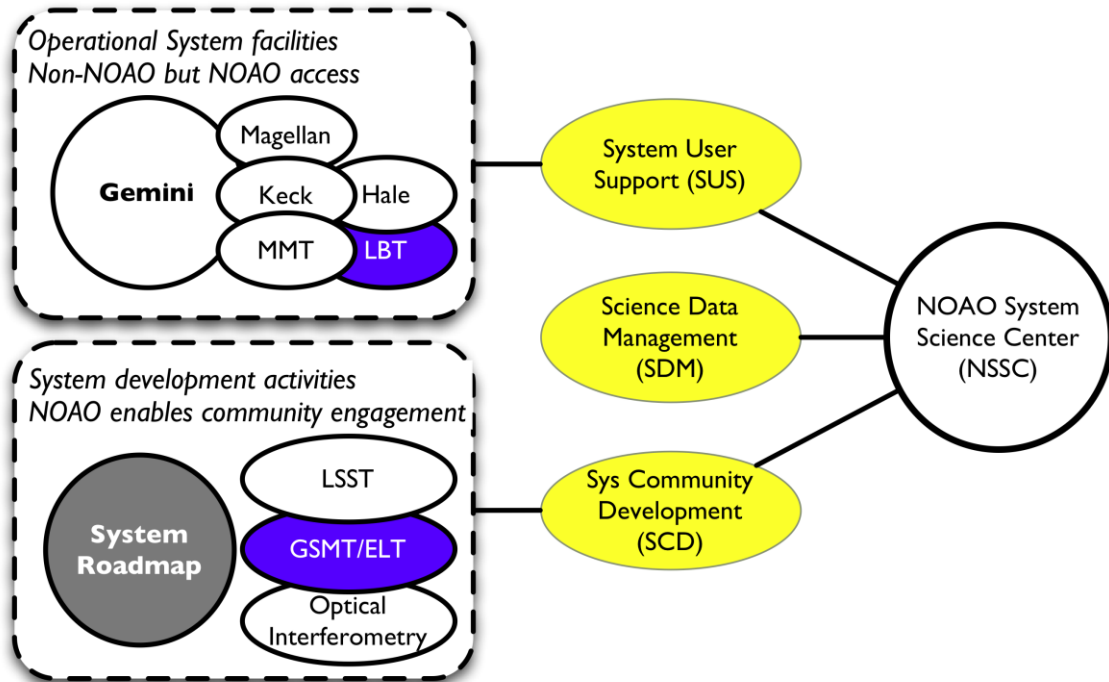


Figure 6: NOAO System Science Center (NSSC)

NSSC organizational structure. Currently, NOAO is **not** engaged directly with LBT and GSMT/ELT, hence those bubbles are shaded *blue*. The System Roadmap is **not** a facility, hence it is shaded *gray*.

4.3.2 System User Support

4.3.2.1 Overview

System User Support (SUS) manages community access to a wide range of telescopes and their instruments beyond those provided by KPNO (including WIYN) and CTIO (including SOAR). Currently, these facilities include the two 8.1-m Gemini telescopes—this access is provided through direct NSF funding—and the telescopes that provide community access in return for TSIP funding: the Keck I and II 10-m telescopes and the MMT 6.5-m telescope. Access via TSIP to the two 8.4-m primary mirrors of the LBT Observatory will begin during this planning period. ReSTAR funding has enabled open-access time to Palomar Observatory’s 200-inch Hale Telescope beginning with observing semester 2010A and extending through 2012B (with an option to extend to 2014B if funding is found). User access to the CHARA optical interferometry is also being supported in FY 2011 under an exploratory agreement between NOAO and CHARA.

4.3.2.2 Major activities

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 help-desk questions from the community, written technical reviews for the NOAO Time Allocation Committee (TAC) on large-telescope proposals 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 Newsletter*, the electronic NOAO newsletter *Currents*, the NSSC Web site, and booths at meetings of the American Astronomical Society (AAS).

4.3.2.3 Major planned deliverables

The major planned deliverables for SUS in this period include:

- *FY 2011*: Improved and reorganized Web pages for locating and using System capabilities.
- *FY 2012*: Be prepared to implement support for future Gemini operations under the new partnership structure (after the withdrawal of the UK), which will begin on 1 January 2013.
- *FY 2013*: Reach first steady-state operations for SUS, with staff flexibility to handle access to new facilities (potentially through ReSTAR-2 funding).
- *FY 2014*: Continue to provide user support on what is expected to be an increasingly enhanced US ground-based system of telescopes within a constrained staffing envelope at NOAO.
- *FY 2015*: Work with both System Community Development and Science Data Management groups within NSSC on the expected impact that LSST operations, especially follow-up observations, will have on SUS staff duties.

4.3.2.4 Anticipated challenges and opportunities

Given the recommendations of the ALTAIR report, which include a call to increase open-access time significantly on 8- to 10-m telescopes and argue for a larger US share in Gemini (provided Gemini becomes more aligned with US community needs), there is a real possibility that NOAO-managed time on the large-aperture telescopes will increase. Any raise in the number of submitted proposals or number of programs scheduled on the telescopes will increase NOAO support levels. It will be a challenge to prudently manage and shepherd the ability of our staff to support more access; this will require planning and streamlining the process by which NOAO manages this time. With increased open-access time, however, comes increased scientific opportunities for the user community.

On long timescales, the deliberately designed fluidity, flexibility, and generally organic nature of a broad, ground-based, open-access system will be a challenge to manage in terms of matching staff expertise to the System capabilities. In such a system, NOAO will also be dealing with a number of different organizations (be they non-federal US or international observatories, as well as universities) with sometimes disparate interests. All of this often requires delicate scientific planning coupled with some measure of diplomacy.

4.3.3 System Community Development

4.3.3.1 Overview

NSSC is responsible for the System Community Development (SCD), which has two important aspects. The first addresses extant projects, such as LSST, GSMT, or the existing facilities for optical interferometry, which provide the potential for new science capabilities. For these projects, NSSC staff scientists provide a liaison to the community, both representing community interests and bringing these capabilities to the attention of the community. The second role for SCD is the engagement of the community in discussions about the System in order to define and prioritize new capabilities for it, such as telescopes, instruments, and data systems.

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, optical interferometry) may be assigned project scientists on a part-time basis. These scientists will likely have other responsibilities elsewhere in NSSC or in the NOAO System Technology Center (NSTC) program.

4.3.3.2 Major activities

System Planning. The System planning activity provides ongoing guidance to decisions about how to utilize resources to advance the System and which capabilities require development. The planning activity will be built around a System Roadmap Committee, with membership drawn from the broad community. The Roadmap Committee activities will generate, on a two-year cycle, a System Status Report and a System Roadmap. The Status Report lays out the current System capabilities and those that are in development. It describes the community's use of the System capabilities over the previous two-year period. The Roadmap identifies the next set of desired capabilities in the context of a longer-term plan. It suggests how existing mechanisms might be used to acquire these capabilities and what new mechanisms or structural changes in the system should be advocated.

GSMT Community Science Development. In the aftermath of the 2010 decadal survey, this activity has been suspended until the intentions of NSF AST are clarified.

LSST Community Science Development. During the next design phase of LSST (through 2012), the community science development activity will concentrate on representing community science interests to the project, either directly, by participating in project discussions, or indirectly, by involving more members of the broad community in these discussions. During the construction phase (2014–2018), the emphasis will be on understanding what tools, hardware, and software the community will need to make best use of the LSST data products, and then developing ways to provide these tools. The impact of LSST and the opening of the time domain will be felt widely throughout the System, and it will strongly influence the development of telescopes, instruments, observing modes, and software tools.

Optical Interferometry Community Science Development. Optical interferometry may be the next technology for ground-based telescopes that will enable transformational advances. The NSSC effort in this area aims to facilitate community access to and use of existing optical interferometry facilities. Over the longer term, it will help these facilities develop a broader presence that will lead to community engagement in planning the next generation of these facilities.

4.3.3.3 Major planned deliverables

The major planned deliverables for SCD in this period include:

- *FY 2011*: Organize a community workshop on Science with Optical Interferometry. (This was completed early in the third quarter of FY 2011.)
- *FY 2012*: Produce a System Status Report followed by a System Roadmap update. Develop and manage a program to provide federal support to optical interferometry facilities and access to the community.
- *FY 2013*: Begin experiments to simulate LSST-scale community use of time-domain data.
- *FY 2014*: Produce the next System Status Report followed by a System Roadmap update.
- *FY 2015*: Deploy test versions of software tools that will be available to the community to best use LSST data, such as time-domain or transient observations.

4.3.3.4 Anticipated challenges and opportunities

The success of the System Community Development program will, in large part, depend on factors beyond the control of this group, or even NOAO. Beyond understanding what capabilities the community would like to have, the primary goal will be to find ways to direct (new) resources to provide new capabilities. The availability of such resources will be limited by economic conditions as well as competing uses outside of O/IR astronomy.

A second challenge will be to evolve the community's perception of the System from a purely descriptive name to a structure with agreed-upon goals and strategies for achieving those goals. It will require both leadership and flexibility to develop mechanisms that induce the private players to include some of these System goals in their decisions.

The opportunity, however, is substantial. As it moves forward, NOAO will use the recommendations of the 2010 decadal survey (and, pragmatically, the subsequent NSF reactions) as the guiding principles for its program.

4.3.4 Science Data Management

4.3.4.1 Overview

Science Data Management (SDM) serves the 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 appropriate, SDM will provide user cookbook and operator manuals to support its deliverables.

4.3.4.2 Major activities

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

SDM Systems Development (SDM-D). 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 is participating in the ODI pipeline design and development within a larger WIYN-led collaboration. SDM-D also maintains core IRAF on various platforms and provides extensions as necessary to be consistent with the NOAO mission.

SDM-D works with groups from eight other major astronomical institutions in support of the Virtual Astronomical Observatory (VAO)¹⁶. The major areas in which SDM contributes to the VAO are: the development of robust services that will enable astronomers to discover, access, integrate, and analyze the vast quantities of astronomical data available electronically; providing a very responsive user support effort for these services including quality assurance and training; and leadership in international cooperative efforts coordinated by the International Virtual Observatory Alliance to standardize data access and discovery protocols, especially in the areas of time domain and VOEvent.

4.3.4.3 Major planned deliverables

The major planned deliverables for SDM in this period include:

- *FY 2011*: Deploy DECam Community Pipeline into the SDM End-to-End (E2) System. Provide support for KOSMOS (archiving raw data and developing data reduction cookbooks). Develop a new image display for large images. Continue participation in ODI Science Pipeline development. Deliver reduced images (and associated data products as appropriate) for all Mosaic, NEWFIRM, ODI (if commissioning is completed on-schedule), and DECam (if commissioning is completed on schedule, and if not, when it is completed) projects executed by NOAO users.
- *FY 2012*: Provide full support for DECam including archiving all raw data and pipeline processing and archiving community data. Continue data capture and archive support for all NOAO instruments. Continue operation of NOAO science pipelines. Update the IRAF FITS kernel. Deliver a data calibration and reduction cookbook for KOSMOS (in collaboration with NSSC/SUS). Deliver reduced images (and associated data products as appropriate) for all Mosaic, NEWFIRM, and DECam projects executed by NOAO users and provide pipeline support for ODI data.
- *FY 2013*: Continue archive, science pipeline, and data reduction support for NOAO instrumentation. Deliver a data calibration and reduction cookbook for COSMOS (in collaboration with NSSC/SUS).
- *FY 2014*: Continue archive, science pipeline, and data reduction support for NOAO instrumentation. Archive TripleSpec raw data and provide a data calibration and reduction cookbook for it.
- *FY 2015*: Work with SCD on testing LSST software tools that will be available to the community to best use LSST data and to plan follow-up observations.

4.3.4.4 Anticipated challenges and opportunities

As SDM continues to provide archive and pipeline reduction support for current instrumentation, the program will be challenged to provide support as well for new instrumentation and the VAO. Resources are very limited, and careful planning is essential to provide the

¹⁶ Caltech, High Energy Astrophysics Science Archive Research Center, Infrared Processing and Analysis Center, The Johns Hopkins University, National Center for Supercomputing Applications, National Radio Astronomy Observatory, Smithsonian Astrophysical Observatory, and Space Telescope Science Institute.

required support on schedule. The data rates from new instrumentation will also require an innovative solution for our data storage needs.

By the end of FY 2011, 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 2011 are still to be determined and depend on available funding and requirements from primary stakeholders throughout NOAO.

The biggest financial challenge for SDM is the acquisition and administration of hardware systems, especially for data storage. During FY 2011, relevant plans will be reviewed and updated to allow proper out-year budget planning.

4.3.5 TAC Team

4.3.5.1 Overview

The NOAO Time Allocation Committee (TAC) is charged with the scientific assessment and ranking of observing proposals for all NOAO-coordinated facilities (KPNO, 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 NSSC director is responsible for the efficient, open, and fair operation of the TAC.

4.4 NOAO System Technology Center

4.4.1 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 that are needed to realize new telescope projects or to enhance the instrument complements on existing US O/IR System telescopes operated by NOAO or other entities. NSTC activities and functions are executed using resources and personnel in Tucson and La Serena.

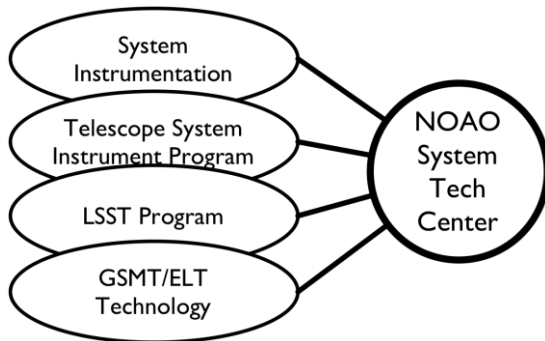


Figure 7: NOAO System Technology Center (NSTC)

NSTC organization

The NSTC incorporates three programs serving these goals:

- **System Instrumentation (SI) program** – directs the efforts of NOAO to build new instruments for its own telescopes, for the Gemini telescopes, and for other telescopes participating in the System.
- **Large Synoptic Survey Telescope (LSST) program** – provides scientific, engineering and management support to the LSST Project and is responsible for telescope mount, enclosure design, and site work within the LSST partnership.
- **Telescope System Instrumentation Program (TSIP)** – 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. NSF funds TSIP independently of the NOAO base budget. NSF has suspended this program starting in FY 2012.

The former GSMT Project Office has been suspended until NSF AST clarifies how it will engage with GMT and/or TMT and, hence, how NOAO will be involved in that effort.

4.4.2 System Instrumentation

4.4.2.1 Overview

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).

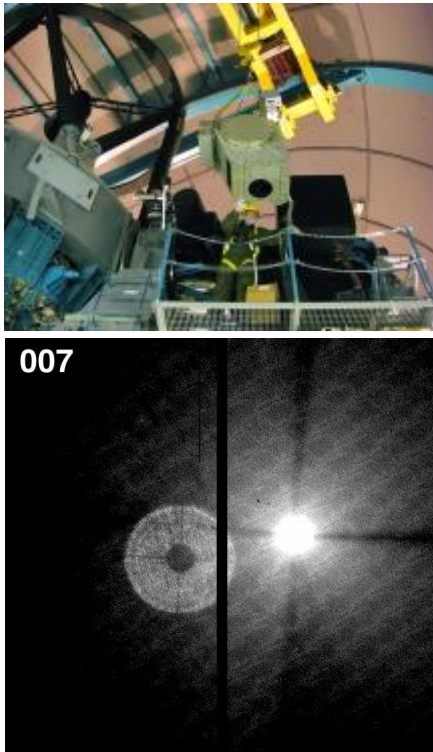


Figure 8: SOAR Adaptive-Optics Module (SAM)

Top: SAM main module being installed on SOAR for initial commissioning run in 2009.

Bottom: U-band images on SOAR Optical Imager of laser guide star (LGS) in first on-sky laser operation. Bright spot is Rayleigh backscatter from LGS beam; “halo” is severely defocused nearby bright star.

4.4.2.2 Major activities

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 was planned for commissioning in two phases. Phase 1 was completed in FY 2009 with the first successful tests of the adaptive-optics bench in natural-guide-star mode. The second phase in FY 2011 will integrate and test the laser-guide-star mode. Commissioning for scientific use will begin in FY2011 and continue into FY 2012. When completed, this system will make possible image quality enhancements that can turn 0.8-arcsecond FWHM natural seeing into approximately 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 reengineering 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 reengineering and repackaging allowed testing of prototypes during FY 2010. During FY 2011, 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. During FY 2009 and 2010, NOAO was awarded \$6.9 million for the first year of Phase 1 of ReSTAR implementation. With some of that funding, SI is constructing three new instruments and upgrading two existing instruments.

The first two new instruments using ReSTAR funds are the Kitt Peak-Ohio State Multi-Object Spectrograph (KOSMOS) and the Cerro Tololo Ohio State Multi-Object Spectrograph (COSMOS). As the names suggest, these instruments are being built in close partnership with the instrumentation group at The Ohio State University. KOSMOS/COSMOS are closely modeled on the OSMOS spectrograph currently in operation at the Hiltner 2.4-m telescope at MDM Observatory on Kitt Peak.

The third new instrument will be a near-copy of the successful TripleSpec near-infrared spectrograph. The SI 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. Also, this fully cryogenic instrument is mechanically more challenging than a visible-light spectrograph. Hence, the project will require a little more time before the launch of actual construction. Development of this instrument is expected to require about 30 to 36 months after a start in mid-FY 2011, leading to a delivery to the CTIO Blanco telescope sometime late in FY 2013 or early FY 2014.

The other projects funded with this initial award are the CCD and controller upgrades for the Mosaic-1 imager (on the KPNO Mayall 4-m) and the Hydra-South spectrograph (on the CTIO Blanco 4-m). The former project was completed in early FY 2011. The latter project will be completed in FY 2012.

Gemini instrumentation. As noted in the ALTAIR report, there is substantial need within the US community for a new workhorse optical spectrograph on one of the Gemini telescopes. In particular, Gemini is the only 8-m-class observatory without a high-resolution optical spectrograph. Gemini Observatory has expressed considerable interest in adding such a capability, and NSTC staff have engaged in informal discussions with Gemini staff



Figure 9: TripleSpec

TripleSpec mounted on the Palomar Observatory 200-inch Hale Telescope.

about possible configurations and costs. Based on community surveys conducted through NSSC, NOAO believes that a highly efficient, fixed-format instrument is the most cost-effective way to serve most of the scientific needs of the US astronomical community. In FY 2011, NSTC has begun modest conceptual design work to evaluate the feasibility of a Cassegrain-mounted spectrograph. The intent of this effort is to be ready to respond quickly as soon as funds for the instrument can be identified. If funding could be found in time, preliminary design work could begin in early FY 2012, and the instrument could be ready for on-telescope integration around or shortly after the end of the current LRP period.

4.4.2.3 Major planned deliverables

The major planned deliverables for SI in this period include:

- *FY 2011:* Complete SAM system integration and begin commissioning and science verification. Begin integration of TORRENT controllers into existing instruments at CTIO and KPNO. Complete successful conceptual design review for a new facility-class instrument for Gemini as discussed in section 4.4.2.2 above.
- *FY 2012:* Complete SAM commissioning and release for science operations. Deliver and commission KOSMOS/COSMOS instruments. Deploy upgraded Hydra-South spectrograph at CTIO Blanco 4-m telescope. Continue integration of TORRENT controllers into existing instruments at CTIO and KPNO. Complete successful conceptual design review for a new facility-class instrument for Gemini as discussed in section 4.4.2.2 above.
- *FY 2013:* Completed detailed design review and begin fabrication of a new facility-class instrument for Gemini (see section 4.4.2.2 above).
- *FY 2014:* Deliver and commission TripleSpec at Blanco 4-m telescope.
- *FY 2015:* Deliver and commission a new facility-class instrument for Gemini (see section 4.4.2.2 above).

4.4.3 Telescope System Instrumentation Program

4.4.3.1 Overview

The Telescope System Instrumentation Program (TSIP) is administered by NOAO and funded by NSF outside of the normal NOAO base budget. Through this program, funding

proposals for instrument projects or telescope operations at non-federally funded observatories are selected to receive NSF funding. In return for NSF funding, these observatories provide observing time to the astronomical community through the NOAO TAC in proportion to the amount of TSIP funds awarded by NSF. 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 funds are spent wisely, and track the scientific success of and user satisfaction with the telescope time provided.

The ALTAIR committee recommended an expanded TSIP program to gain more open access on large-aperture telescopes. The 2010 decadal survey report concurred, albeit at a lower funding level. Unfortunately, NSF has suspended TSIP starting in FY 2012.

4.4.3.2 Major activities

TSIP as currently constituted is an ongoing program in which NOAO's activities as manager are largely the same from year to year. See the deliverables planned in section 4.4.3.3 below, all of which are dependent on the level of supplemental funding received from the NSF for this program.

4.4.3.3 Major planned deliverables

The major planned deliverables for TSIP in this period include:

- *FY 2011*: Announce call for proposals, convene community panel to review proposals and make funding recommendations to NSF based on panel's report, and award funds to successful proposals as approved by NSF. Execute funding subawards with successful proposers. Oversee and administer existing subawards from prior years, closing them out as projects are completed.
- *FY 2012*: No activity planned unless NSF funding is restored.
- *FY 2013*: No activity planned unless NSF funding is restored.
- *FY 2014*: No activity planned unless NSF funding is restored.
- *FY 2015*: No activity planned unless NSF funding is restored.

4.4.4 NOAO LSST Program

4.4.4.1 Overview

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 35 institutions, including universities, Department of Energy (DOE) laboratories, and private organizations. LSSTC submitted a revised construction proposal to NSF's Major Research Equipment and Facility Construction (MREFC) program in January 2011 requesting \$312.7M (then-year dollars with 25% contingency) from the NSF toward the project cost.

Here, NOAO assumes that LSST will be an MREFC new start in FY 2014.

Figure 10: Large Synoptic Survey Telescope (LSST)

Computer rendering of LSST facility design on top of Cerro Pachón, just south of the existing Gemini South and SOAR facilities.



4.4.4.2 Major activities

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 activities is in the telescope subsystem development. This includes the full articulating telescope structure, optics, summit facility, dome, control system, and support facilities such as the coating chamber and photometric monitoring telescope. It also includes the 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, independent of the LSST Corporate Project, and 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 LSSTC through the Science Advisory Council, developing specialized 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 science collaboration proposals has succeeded in bringing on a new collaboration and adding over 100 additional US scientists into the 11 science-based collaborations. There are now 451 scientists involved in the collaborations.

Funding to support the LSST efforts at NOAO stems from the base budget and has been augmented with supplementary funds specifically for LSST Design and Development. The LRP continues the base support for the NOAO LSST Program through FY 2013. 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.

The assumption is made that the LSST Project will work separately with the NSF to continue providing supplemental funding with the Design and Development Grant.

If LSST is recommended for construction and if construction funding is allocated, some NOAO engineers working on LSST will be funded by LSST construction funding toward the end of this LRP planning period. However, NOAO scientists will not be funded by construction allocations; therefore, 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.

4.4.4.3 Major planned deliverables

The major planned deliverables for the NOAO LSST Program in this period include (assuming an MREFC new start in FY 2014):

- *FY 2011:* A completed design review of the Telescope and Site system provided in support of the Project Preliminary Design Review and corresponding DOE reviews. This will also include the completion of several contracted design activities and the testing of several hardware prototypes. The architectural and engineering design of the summit facility will be completed.
- *FY 2012:* 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 early contractor selection and rapid contract starts upon MREFC authorization. Procurement packages will be completed and openly competed for several of these long-lead systems (i.e., mount and secondary mirror).
- *FY 2013:* The Telescope and Site designs, including those elements addressed by contracted vendors, will be completed for a final design review and complete cost and schedule audit. With the key vendors already chosen and costs negotiated, a very solid cost basis will be in hand, and preparations will be made for a smooth transition into construction.
- *FY 2014:* The Telescope and Site team will be completely mobilized with the assumed 2014 construction authorization. The current group of 14 will be increased to 25 through temporary assignments from NOAO personnel in other departments (six FTE are already involved from other groups) and several new hires. All major contracts will be issued to support the four-year construction period that is followed by the two-year commissioning period.
- *FY 2015:* The summit facility will be completed and integration of the dome started. Telescope will be in final testing at the contractor, and the primary mirror support cell will be completed. Base facility design will be started.

4.4.5 GSMT/ELT Technology

4.4.5.1 Overview

Although not a formal partner in any Giant Segmented Mirror Telescope or Extremely Large Telescope (GSMT/ELT) project, NOAO continues to provide engineering assistance to the Giant Magellan Telescope (GMT) and Thirty Meter Telescope (TMT) projects upon request and on a cost-recovery basis.

4.4.5.2 Major activities

This is an ongoing activity, and both the quality and quantity of the assistance given depend entirely on the requests from the TMT and GMT projects.

4.4.5.3 Major planned deliverables

Subject to further direction and funding by NSF, there are no planned deliverables in this area at this time.

4.4.6 Anticipated 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; the LSST effort is expected to remain essentially constant until MREFC funding is received, and then to increase dramatically with a requisite need for additional staff. The ReSTAR instrument developments are also expected to require engineering talent, and it may be necessary to hire one or more additional engineers using the supplemental ReSTAR funding.

If funds were 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 ReSTAR report provides other examples. The Phase 1 implementation proposal provides for only a few of the most urgent recommendations. For example, further supplemental funding beyond the Phase 1 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.

4.4.7 Special topic: development of instrumentalists**4.4.7.1 ReSTAR subprogram: 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 with 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.

4.4.7.2 Technology post-docs

When the current cooperative agreement was negotiated, NOAO committed to funding one to two post-doctoral fellows for astronomical technology development, starting in FY 2012. These post-docs would have been 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 would have been especially encouraged. Unfortunately, NSF AST has not been able to provide the funding necessary to support this initiative.

4.5 NOAO Directorate

4.5.1 Overview

The NOAO Directorate encompasses the management and administrative functions that affect all NOAO staff, provide public and educational outreach, and encourage participation of underrepresented groups and diverse institutions. Those functions are handled by the following groups:

- NOAO Director's Office
- Central Administrative Services
- Human Resources
- Office of Science
- Broadening Participation
- Education and Public Outreach

4.5.2 NOAO Director's Office

4.5.2.1 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 for the production and delivery of NSF-required reports such as the Annual Program Plan and the Long-Range Plan.

The NDO is led 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 for specific tasks (e.g., report generation and submission). When appropriate, various NOAO scientists are assigned part-time to the NDO to execute specific functions (e.g., Diversity Advocates).

4.5.2.2 Support offices

Risk management. 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. The risk manager has supported other organizations when requested, including Gemini, NSO, WIYN, 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, the risk manager is responsible for managing industrial insurance as the AURA Insurance Program administrator.

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

NOAO library (Tucson). The NOAO library in Tucson is run by one full-time librarian, who reports to the NOAO director. The librarian has three main responsibilities: (1) maintain the Tucson library collection, including periodicals; (2) gather publication statistics as required by NSF; and (3) assist in the management of the NOAO library in La Serena.

Report management. NSF requires that NOAO submit many reports per year. A half-time employee is responsible for collecting all required information and data and producing each report on behalf of the NOAO director.

Compliance. NOAO operates within a regulatory regime established by NSF in combination with applicable directives from other federal agencies. NOAO also must comply with regulations imposed by state and local authorities as well as the Tohono O'odham Nation, where applicable. Regulatory extent and complexity continue to expand with time. The NOAO chief compliance officer (CCO) is responsible for regulatory compliance oversight on behalf of the NOAO director.

AURA remains responsible for regulatory compliance with Chilean agencies. As necessary and appropriate, the NOAO CCO assists AURA in such matters.

Science staff promotion and tenure. The NOAO director appoints the NOAO promotion and tenure (P&T) committee. An *ex officio* member of the committee is the Office of Science head of program. On behalf of the director, the P&T committee performs the following functions in a manner consistent with relevant policies established by AURA:

- Promotion reviews for scientists and tenure-track scientists
- Fourth-year (pre-tenure) reviews for tenure-track scientists
- Tenure reviews and preparation of tenure documentation for review by the AURA Observatory Council
- Post-tenure reviews

4.5.3 Central Administrative Services

4.5.3.1 Overview

Central Administrative Services (CAS) provides administrative (business) services for NOAO. In addition, it provides full or partial administrative support to affiliated institutions and observatories, including the National Solar Observatory (NSO), Gemini, WIYN Corporation, SOAR Consortium, LSST Corporation, SMARTS Consortium, and AURA Corporate. Non-AURA work is done on a fee-for-service basis as defined in individual business service agreements.

4.5.3.2 Major activities

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
- Sponsored projects
- Procurement
- Import/export
- Business IT

Development, communication/training, and oversight of the administrative processes 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.

CAS works in conjunction with NOAO South Administration to coordinate accounting, audit, compliance, contracts, exporting, and budgeting. CAS continues to work to fully integrate accounting systems and reporting with NOAO South. Official reporting for all of NOAO remains in Tucson.

Over the next five years, CAS will review and revise procedures and investigate the need to upgrade systems to meet the demands of increased regulations and new cooperative agreement provisions. This will be accomplished in part by revising and expanding current Web-based systems for requisitioning (Reqless), budgeting (WEBUD), accounting reports (CASNET), and document storage. Utilizing new developments and technology to effectively improve its services, CAS will be able to provide not only basic administrative support but also remain current on best practices, compliance requirements, and administrative developments affecting the organization and the NOAO community.

As noted above, CAS provides expertise and leadership to NOAO affiliates and other AURA Centers. CAS especially acts as the point of contact and support for export/import issues and shipping/receiving to Chile, as well as for legal, audit, and general compliance. 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 maintain 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.

4.5.3.3 Major planned deliverables

Major planned deliverables for CAS in this period include:

- *FY 2011*: Complete integration of NOAO South Administration into CAS systems.
- *FY 2012*: Prepare for scheduled NSF Business Systems Review, assist the NSF committee, and respond to the AURA Management Review. Conduct comprehensive review of business IT systems.
- *FY 2013*: Upgrade or install new financial and reporting software as recommended by a systems review.

- *FY 2014*: No specific projects currently planned.
- *FY 2015*: No specific projects currently planned.

4.5.3.4 Anticipated challenges and opportunities

CAS is constantly challenged to meet time-lines and balance priorities. In addition, aging staff demographics require the need to develop transitional expertise in a timely manner. This provides an opportunity to review NOAO program needs in conjunction with affiliate and community support.

4.5.4 Human Resources

4.5.4.1 Overview

The NOAO Human Resources (HR) manager reports directly to the NOAO director. HR is dedicated to developing internal and external partnerships that facilitate the organization's long-range plan through recruitment and retention, performance management, compensation and benefits, training and development, as well as employee relations and compliance. The NOAO HR group provides support to NOAO active and retired staff as well as AURA employees assigned to the National Solar Observatory (NSO), LSST, and the WIYN Observatory.

4.5.4.2 Major planned deliverables

Major planned deliverables for HR in this period include:

- *FY 2011*: Put into service a new recruiting software module to automate the entire recruiting and applicant tracking process to help reduce the length of the recruiting cycle and to be more strategically set for anticipated increases in recruitment activities. Revise the current performance management system to improve linkage with organizational objectives and employee motivations. Improve HR support to NOAO South.
- *FY 2012*: Continue the review and documentation of current HR procedures and processes. Develop a supervisory/management training program for new managers and supervisors.
- *FY 2013*: No specific projects currently planned.
- *FY 2014*: No specific projects currently planned.
- *FY 2015*: No specific projects currently planned.

4.5.4.3 Anticipated challenges and opportunities

As the NOAO workforce changes and more employees become eligible for retirement, maintaining a skilled workforce as well as maintaining an attractive benefits package with ever increasing costs will prove to be a challenge to Human Resources. Human Resources is positioning the observatory to contain benefits costs by introducing wellness programs in the workplace in conjunction with the NOAO healthcare vendor to lead employees to healthier and more productive lifestyles.

4.5.5 Office of Science

4.5.5.1 Overview

Members of the NOAO scientific staff are contractually allowed to spend up to a defined fraction of their time on personal scientific and/or technical research. The mission of the

Office of Science (OS) is to support and encourage such research activity. The OS also provides support for activities related to scientific staff evaluation and promotion. Specific activities include:

- Enhance the scientific environment at NOAO and ties to the local academic astronomy community
- Represent the NOAO scientific staff to the NOAO director
- Provide resources in support of the research efforts of the scientific staff
- Support the Steward-NOAO Joint Colloquium series, NOAO South colloquia, Friday lunch talks (FLASH), and Science Coffees and Teas
- Support the Goldberg Fellowship program
- Host and fund scientific workshops
- Edit *Currents*, the NOAO electronic newsletter

The OS head of program is an *ex officio* member of the NOAO Promotion & Tenure committee.

4.5.5.2 Major activities

Major activities of the Office of Science include:

- Provide mentoring for post-docs and junior staff
- Develop guidelines for scientific staff searches in collaboration with NOAO diversity advocates
- Assist in developing and maintaining a Responsible Conduct in Research (RCR) implementation policy that is consistent with federal guidelines and AURA policy
- Sponsor and help to organize community workshops on upcoming instruments (DECam, BigBOSS)
- Enhance the interaction between the scientific staffs in the north and south
- Explore additional programs, such as a visiting student program

4.5.5.3 Major planned deliverables

Major planned deliverables for OS in this period include:

- *FY 2011*: Continue promotion, tenure, and post-tenure reviews and recommendations. Continue mentoring and explore possibility of a broader program. Continue to improve the scientific environment. Develop scientific staff hiring guidelines and an RCR implementation policy. Assist the NOAO director with developing future long-range plans.
- *FY 2012–2015*: Steady-state, see FY 2011.

4.5.5.4 Anticipated 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, and 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 (although some programs are an effective mix of ground- and space-based observing). An informal, pilot, visiting student program may be helpful in this context. This program is not likely to meet the demand for students at NOAO, but it allows NOAO to develop the support structure needed to expand the program if funding becomes available.

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 (e.g., 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. The recent Gemini instrumentation workshop is a successful example of a limited program of this kind. NOAO does not have the funding or staff time to further develop and implement this concept on a broader scale at the present; but, it may be possible to find funding in the future.

4.5.6 Broadening participation

NSF asserts that broadening participation in the US science enterprise must be a key component for all NSF-supported programs. As summarized on NSF's Broadening Participation Web page,¹⁷ 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.**”

To further quote from Broadening Participation at the National Science Foundation: A Framework for Action (2008):¹⁸

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.

¹⁷ www.nsf.gov/od/broadeningparticipation/bp.jsp

¹⁸ www.nsf.gov/od/broadeningparticipation/framework_report.jsp

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.

4.5.6.1 NOAO Diversity Advocates

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.¹⁹

In support of this commitment, NOAO has appointed two Diversity 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:

- Workplace 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 elsewhere in this document. Obviously, NOAO efforts in these areas can and will evolve in the years ahead.

4.5.6.2 NOAO and REU

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 10–12 weeks over the summer.

¹⁹ www.aura-astronomy.org/about/diversity.asp

Figure 11: 2010 REU cohorts

NOAO North (top), NOAO South (bottom)



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 programs.

4.5.6.3 NOAO and PAARE

In recent years, NOAO engaged with the NSF-funded Partnerships in Astronomy & Astrophysics Research and Education (PAARE) program. The first five-year NOAO PAARE partnership (A Partnership in Observational and Computational Astronomy, POCA) is with Professor Don Walter of South Carolina State University, a Historically Black College/University (HBCU)²⁰. The first NOAO POCA undergraduate student spent the summer of 2009 at NOAO North and worked with KPNO and NSO REU students from June through mid-August.

The second five-year PAARE partnership (Graduate Opportunities at Fisk in Astronomy and Astrophysics Research, GO-FAAR) is with Professor Keivan Stassun of Fisk University, an HBCU²¹. The first GO-FAAR participant started working at NOAO South in January 2010.

Starting in FY 2012, NSF AST has terminated the PAARE program, due to a general lack of participation. If similar programs emerge in the years ahead, NOAO will seek to participate.

²⁰ 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.

²¹The five-year GO-FAAR program (Graduate Opportunities at Fisk in Astronomy and Astrophysics Research) (PI: Keivan Stassun) is funded by the NSF through the grant AST-0849736.

4.5.7 Education and Public Outreach

4.5.7.1 Overview

Education and Public Outreach (EPO) provides the following main deliverables:

- 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/education community
- Media relations

Related secondary deliverables provided by EPO include:

- Development and maintenance of the central NOAO Web presence
- Development and orchestration of the NOAO booths at AAS meetings
- Management of the creation and delivery of the semi-annual *NOAO Newsletter*
- Support for *Currents*, the NOAO electronic newsletter

4.5.7.2 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, with the research community, and with the astronomy education 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 and informal science educators (e.g., museum and afterschool program educators). 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 video-conferencing to link the EPO professionals from both sites and to connect students and student programs in Arizona and Región de Coquimbo.

Professional service is an important activity of the EPO group, and EPO staff are in high demand (because of their skill and experience) to assist and advise NSF projects and professional organizations.

Key programs include:

- **Project ASTRO** – a teacher-scientist partnership program for the Tucson region
- **Centro de Apoyo a la Didáctica de la Astronomía (CADIAS)** – an outreach center near La Serena providing important primary school programs and public programs as well as teacher and observatory guide professional development
- **Tohono O’odham Nation 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 program efforts from the now-completed national program that are conducted in the Tucson area and at sites across Arizona and the

recent addition to the middle school Hands-On Optics program of a set of adaptive optics activities at the high-school level

Other NOAO projects of importance are:

- **Dark Skies Education** and **GLOBE at Night** – projects that mesh with dark sky education efforts near our observatories in Arizona and Chile including GLOBE at Night, which now has an international presence with its use in over 90 countries
- **Teaching with Telescopes Education program** – builds on the Hands-On Optics and Galileoscope programs with NOAO-developed teaching materials, kits, and professional development programs disseminated nationally to teachers and museum educators and includes professional development of fifth-grade teachers across Arizona and large star parties with Galileoscopes as a culminating activity

When the Public Affairs and Educational Outreach program was restructured as EPO, NOAO had a number of contractual grant responsibilities corresponding with the deliverables above. Two programs will be completed or largely completed during FY 2011:

- Expanding the Hands-On Optics in Arizona (funded by Science Foundation Arizona)
- Building Information Technology Skills through Astronomy (funded by Science Foundation Arizona)

The following projects were completed recently:

- Astronomy From the Ground Up: Building Capacity in Smaller Informal Science Education Institutions (funded by NSF Informal Science Education with partners Astronomical Society of the Pacific and the Association of Science Technology Centers)
- Collaboration to Advance Teaching Technology and Science (NSF GK-12, lead organization is University of Arizona)
- Spitzer Teacher and Student Research Program (with NASA Jet Propulsion Laboratory and Spitzer Science Center)

4.5.7.3 Major planned deliverables

Major planned deliverables for EPO in this period include:

- *FY 2011*: Provide the eight main and secondary deliverables described above. Organize a series of Project ASTRO workshops in Tucson and other Arizona sites. Maintain a vigorous education and outreach program at the CADIAS science center in Chile and with the Tohono O'odham Nation near Tucson. Manage a successful GLOBE at Night program in Arizona and Región de Coquimbo. Create a Teaching with Telescopes (Galileoscope-based) education program in the US and Chile. Seek new outreach grant funding as time allows.
- *FY 2012*: Same as FY 2011.
- *FY 2013*: Same as FY 2012.
- *FY 2014*: Same as FY 2013.
- *FY 2015*: Same as FY 2014.

4.5.7.4 Special topic: Update on EPO Advisory Committee

At the request of the National Science Foundation, NOAO formed an EPO Advisory committee, which first met in March 2009, then on 5–6 April 2010, and is scheduled to meet next on 18–19 April 2011. This committee is charged with evaluating the direction and quality of the existing EPO program and is currently headed by Dr. Roy Gould (Harvard Smithsonian Center for Astrophysics). Other current committee members are Marge Bardeen (Fermi Lab), Ken Brecher (Boston University), Lucy Fortson (University of Minnesota), Kevin McLin (Sonoma State University), and José Francisco Salgado (Adler).

The charge to the committee was primarily to 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. The committee also examined the current programs in the 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.

Overall, the committee was impressed with the NOAO EPO program and its effectiveness in Arizona, the US, and in Chile. The committee made a number of strategic planning recommendations to help focus the overall program and to improve the integration of the NOAO North and South programs.

4.5.7.5 Anticipated challenges and opportunities

The key challenge facing the EPO program is maintaining its national reputation for quality, innovation, and service in Chile and the US given the budget constraints and small number of staff. As grants end, the EPO program must smoothly transition to core funding while maintaining the quality of programs and professional interests and specialties of the few core staff.

Another challenge being addressed is to re-energize media relations without a formally trained public information officer. This is being accomplished through additional training of the EPO manager in the latest, best practices in science communication and media.

NOAO has many opportunities in education and public outreach. NOAO programs such as Hands-On Optics, Teacher Leaders in Research Based Science Education, the Spitzer Teacher and Student Research Program, the undergraduate student outreach cadre, Project ASTRO, GLOBE at Night, and the Galileoscope and Teaching with Telescopes are viewed as highly successful, innovative models by the EPO community. NOAO can play a key role in expanding the reach of these programs to new audiences through strategic efforts to train and collaborate with the astronomy education community and professional organizations such as the AAS, Astronomical Society of the Pacific, Optical Society of America, and SPIE. As many of the NOAO education programs reach underserved audiences, the broader impact of EPO's efforts can be amplified with a modest amount of additional support from base funding and through targeted grants. Additional funding can create high-leverage opportunities to significantly expand these successful programs to serve other underserved audiences. In particular, NOAO staff can play an important role in the professional development of formal and informal educators who work with underserved groups and with minorities underrepresented in science.

5 Management Plan

5.1 Executive Council

The NOAO Executive Council (EC) is the senior management group that advises the NOAO director. Current EC members are:

Program	Title	Name
Director's Office	Director	David Silva
Director's Office	Deputy Director	Robert Blum
KPNO	Associate Director, acting	Abhijit Saha
CTIO, NOAO South	Associate Director	R. Chris Smith
NOAO System Science Center	Associate Director	Verne Smith
NOAO System Technology Center	Head of Program	David Sprayberry

The EC meets face-to-face roughly twice per month. The NOAO director invites other people to these meetings as appropriate. Currently, the following middle managers have standing invitations to EC meetings:

- NOAO South Deputy Director (Nicole van der Bliet)
- Office of Compliance (Karen Wilson)
- Office of Science (Joan Najita)
- Education and Public Outreach (Steve Pompea)
- NOAO Controller (Chris Richardson)
- NOAO North ETS (David Sawyer)
- NOAO South ETS (Tim Abbott)
- NSSC Science Community Development (Todd Boroson)
- NSSC Science Data Management (Betty Stobie)
- NSSC System User Support (Knut Olsen)
- NSTC LSST Project Office (Victor Krabbendam)

5.2 External Committees

NOAO senior managers spend significant time annually interacting with external committees. A brief description of each committee is provided below.

5.2.1 Formal oversight

5.2.1.1 AURA Board of Directors

This is the most senior management council for AURA as a whole. To quote from the AURA Board Web site:²²

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 the AURA Board meetings coincides with the annual meeting of the AURA Member Representatives (see below).

5.2.1.2 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 multiday meeting is attended by the NOAO director and deputy director as well as the associate directors for KPNO, NOAO South, and NSSC. Other NOAO managers may attend as necessary.

5.2.1.3 AURA Observatory Council

Elected by AURA member representatives and subsequently appointed by the AURA Board, the Observatory Council (OC) provides oversight and advocacy for the management of NOAO. In particular, the OC: (1) reviews the NOAO Annual Program Plan and the NOAO Long-Range Plan; (2) reviews the performance of senior managers; (3) oversees recruitment of associate directors and approves the final selection; and (4) reviews tenure cases and makes recommendations to the AURA Board, who have the final authority. 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.

5.2.1.4 NSF Program Review Panel

Appointed by the NSF Astronomical Sciences (AST) 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 NOAO 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 and deputy director always attend these meetings.

5.2.2 Advisory

5.2.2.1 Time Allocation Committee

The Time Allocation Committee (TAC) reviews observing proposals for all of the System 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

²² AURA Board of Directors Web site: www.aura-astronomy.org/g/ag.asp?gid=82

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.

5.2.2.2 NOAO User's Committee

Appointed by the NOAO director, the NOAO User's Committee holds an annual face-to-face meeting to advise the director on all matters related to the scientific use and development 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 committee membership, can be found at www.noao.edu/dir/usercom/.

5.2.2.3 US Gemini Science Advisory Committee

NOAO meets semi-annually with the US Gemini Science Advisory Committee to discuss the US perspective on all matters that bear on the scientific quality and productivity of the Gemini Observatory. The associate director for NSSC attends these meetings. The NOAO director and deputy director attend as time permits.

The committee membership can be found at www.noao.edu/usgp/committees.html.

5.2.2.4 NOAO EPO Advisory Committee

This committee reports to the NOAO director and has been charged with evaluating the direction and quality of the existing EPO program. The NOAO deputy director and EPO head of program attend these meetings.

5.2.3 Partnership boards

5.2.3.1 Large Synoptic Survey Telescope (LSST)

NOAO is an LSST Founding Member.²³ The NOAO director is a member of the LSST Board of Directors. The Board has monthly teleconferences and quarterly face-to-face meetings.

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

5.2.3.2 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 associate director for KPNO and two other NOAO scientists. In addition to the WIYN Board, NOAO has science staff on the WIYN science advisory committee (SAC). The WIYN SAC reports to the WIYN Board and WIYN director.

5.2.3.3 Southern Observatory for Astronomical Research (SOAR)

NOAO is a 33.3% member of the SOAR Consortium and has two seats on the SOAR Board. One of those seats is usually occupied by the associate director for NOAO South. In addition to the SOAR Board, NOAO has science staff on the SOAR SAC, which reports to the SOAR Board and SOAR director.

²³ The LSST Founding Members are: NOAO, Research Corporation, University of Arizona, and University of Washington.

5.2.3.4 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.”²⁴ The NOAO director is the ACCORD co-chair and attends all meetings, which occur in principle at least once per year.

5.2.3.5 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.

5.3 Reports

NSF requires NOAO to produce a significant number of reports and plans throughout the year. NOAO produces other reports and newsletters for the community-at-large. As an ensemble, these reports are one of the chief channels of communication with NSF and the community.

This section provides a list of current reports. The latest versions of many of the reports can be found at www.noao.edu/news/.

5.3.1 Reports required by NSF

NOAO must provide the following reports to NSF on a regular basis:

- Long-Range Plan (annual, due April 30)
- Annual Progress Report (annual, due July 1)
- Fiscal Year Annual Report (annual, due November 30)
- Annual Program Plan (annual, due December 31)
- Quarterly Scientific Reports (for current cooperative agreement/cooperative support agreements and for unexpended funds from previous cooperative agreement)
- Quarterly Federal Financial Reports
- Government-Owned Property Inventory Report (annual, due September 1)

5.3.2 Other scheduled reports

NOAO also typically produces the following reports:

- *NOAO Newsletter* (twice per year, March and September)
- *Currents* (every 6–8 weeks, electronic)
- Response to User’s Committee Report (annual, due August 15)
- Response to NSF Program Review Panel (twice per year, due dates depend on PRP meeting schedule)

²⁴ AURA ACCORD Web site: www.aura-astronomy.org/g/ag.asp?gid=68

6 Challenges

This section summarizes (in bullet form) short-term and mid-term strategic issues that NOAO is tracking.

6.1 FY 2011 Challenges

6.1.1 Financial (potential)

All activities have financial challenges tied to the need to stay within the planned budget and schedule. However some projects are particularly problematic due to “known unknowns” and/or lack of NOAO’s ability to influence events. Finally, there are macro-economic issues to which NOAO has no recourse other than to react. Current potential financial challenges include:

- Likelihood that final FY 2011 base funding will be lower than requested, perhaps significantly
- Likelihood that base funding in FY 2012 and beyond will be significantly less than current NSF projections
- Dollar/Chilean peso exchange rate fluctuations
- Chilean inflation rate changes
- Outcome of biannual negotiations with Chilean labor union
- Desire to complete the WIYN One Degree Imager (ODI) as soon as possible
- Out-year costs of ODI archive operations (especially storage costs)
- Desire to fund Gemini instrument new start (at least design and development phase)
- Possible delay in LSST construction funding, leading to continued need to provide base funding to keep LSST Telescope and Site team together

6.1.2 Programmatic

Programmatic challenges are related to activities to be completed this fiscal year that have known complexity and/or high priority. Known challenges include:

- Preparation for and outcome of strategic review of NSF AST portfolio (FY 2011–2012)
- Outcome of current international discussion of future relationship of NOAO and Gemini (FY 2011 and beyond)
- Managing ARRA/ReSTAR surge of activity during FY 2011 and FY 2012
- General need to review and tune Environment, Safety, & Health (ESH) effort (sometimes known as “risk management”)
- Given unhappiness uncovered during last union negotiation, need to probe local staff concerns in La Serena and develop responses as appropriate

- Complete inventory of NOAO engineering/technical team skill mix and head count to facilitate long-term planning
- Make decision about next major in-house instrumentation or technology development project
- Respond to increase in regulatory and financial oversight by NSF
- Be ready to react to Gemini organizational changes, if/when they have an impact on NOAO activities, especially in La Serena

6.2 Mid-Term Challenges

Over the next 12–36 months, several events are likely to have a significant impact on the strategic direction of NOAO. NOAO must stay aware of these events and be prepared to react as promptly and agilely as possible.

These events include:

- Preparation for and outcome of recompetition of cooperative agreement for management of NOAO (FY 2013–2014)
- Sustaining System development (on-going)
- LSST construction and operations preparation ramp-up
- GMT and/or TMT engagement (depends on NSF)
- NOAO Tucson and La Serena base facility infrastructure renewal

7 Budget Projection

7.1 FY 2011

The first four columns in the budget table in Appendix A summarize the FY 2011 budget and funding. In some cases, these numbers differ from the values given in the NOAO Annual Program Plan FY 2011 (APP-11) due to: (1) minor accounting (not scope of work) adjustments made after APP-11 was submitted to NSF, and (2) scope-of-work changes made to adjust from the \$28.33M planning target (FY 2011 President's Request) to the actual FY 2011 allocation of \$27.5M.

These columns are:

- **Total Budget** – the total (spend) budget for each work package.
- **Carryover** – funding from FY 2010 carried forward to FY 2011. In most instances, these carryover funds are from projects funded in FY 2010 (or earlier) but scheduled for completion in FY 2011 or later. Two examples are the ReSTAR implementation projects (e.g., KOSMOS) and LSST design and development work.
- **Other Funding** – estimates of payments received for services provided. Typical examples are payments received for infrastructure operation and maintenance on Kitt Peak, Cerro Tololo, and Cerro Pachón that is provided to non-NOAO facilities (“tenants”).
- **NSF Base Funding** – distribution of base funding provided by NSF.

When approved by the AURA OC in November 2010, this plan had a projected total FY 2011 **uncommitted reserve** of \$0.997M. After the adjustments discussed above, this number increased to \$1.204M. As a reminder, a reserve is necessary to allow for:

- Unpredictable US dollar to Chilean peso exchange rate fluctuations
- Larger-than-planned inflation in US or Chile
- High-level project contingency
- Sudden cash needs for unpredictable events (e.g., weather damage to facilities)
- Ability to respond to sudden opportunities
- Seed money for later excellence (e.g., design and development work to support a funding request for new instrumentation)

7.2 FY 2012

For FY 2012, the NSF requested \$29.17M for base funding (a 6% increase over FY 2010 and 2011 actual of \$27.5M) and nothing for TSIP.

NOAO has elected to pursue a conservative budgeting strategy for FY 2012.

1. Only \$27.95M will be distributed to NOAO work elements. A close-to-final distribution is shown in the budget table. The final planned distribution will be reported in the NOAO Annual Program Plan FY 2012.
2. The remaining \$1.22M (= \$29.17M – \$27.95M) is held as uncommitted reserve. In addition to the potential operational risks stated above, this reserve provides partial

protection against the probability that the actual FY 2012 funding allocation will be less than the requested FY 2012 funding level.

Only projected base funding distributions are shown for FY 2012. Explicit projected revenue, carryover, and total budget numbers for each work package are not shown for FY 2012. In general, NOAO assumes the following:

- **Revenue** – the basket of operations and business services provided to external entities in FY 2012 will remain the same in FY 2011. Therefore, revenues also will remain the same, adjusted according to NSF guidelines. Changes in level of service will be matched by changes in level of revenue. Such changes need to be monitored carefully to: (1) prevent overload of current staff if service requests increase (NOAO will hire new staff covered by new revenue wherever possible), or (2) prevent NOAO from becoming sub-critical in some skill set if service requests decrease and staff size must decrease due to decreased revenue.
- **Carryover** – carryover funds for specific projects (e.g., LSST) will be assigned to those projects at the end of FY 2011. General carryover (e.g., general expenditures less than projected) will be placed in the reserve budget or assigned to specific projects on a case-by-case basis. It will **not** be used to balance the budget of the next fiscal year in the event of less-than-predicted NSF base funding unless absolutely necessary.

The AURA fee is set to \$0.873M and has two parts: (a) a Facilities and Administration overhead fee (2.48% of \$29.15M), and (b) a fixed-value management fee of \$0.15M.

No new supplementary funding has been shown for FY 2012. However:

- Some **ARRA** and **ReSTAR Phase 1** projects will not be completed until FY 2012 and 2014, respectively, so there will be carryover from FY 2011 to FY 2012 for these specific projects.
- No funding has been shown for **ReSTAR Phase 2**. In any case, if such funding does materialize, it will mostly flow through NOAO to external organizations.
- **REU** North and South programs are expected to receive continued funding, although perhaps not every year.
- **LSST** will receive additional supplementary funding from NSF for further design and development activity.
- NOAO has submitted a proposal to design a new **Gemini instrument**, the Gemini High-resolution Optical Spectrometer (GHOS). If NOAO is funded in the build phase of this instrument, supplementary funds will be provided by the Gemini partnership in FY 2012 and beyond.

NN ETS and NS ETS are currently in transition from being tightly integrated with KPNO and CTIO, respectively, to being more clearly separated for better management and tracking. Explicit FY 2011 budgets for these groups were not created—their funding was still buried in CTIO, KPNO, and NSTC. For FY 2012, site-specific technical development and maintenance activity (e.g., major telescope upgrades and system renovations) is budgeted under NN-ETS and NS-ETS. However, instrument development activity is budgeted under NSTC-SI, to reflect the matrix nature of this activity.

Likewise, here in FY 2012, the budgets for Human Resources and Broadening Participation are buried in the budgets for Central Administrative Services and the NOAO Director's Office, respectively.

7.3 Out Years: FY 2013–2015

Beyond FY 2012, several events are likely to have a major impact on the NOAO program, and they include the following:

- Outcome of NSF AST strategic portfolio review (impact not before FY 2014)
- Competitive review and award of cooperative agreement for management of NOAO (impact not before FY 2014)
- LSST construction start (impact not before FY 2014)
- Reorganization of Gemini partnership and how the partnership governs itself (fiscal year of impact uncertain)
- Increase (or decrease) in System development funding, e.g., ReSTAR, TSIP (fiscal year of impact uncertain)

NOAO has adopted the following programmatic and financial assumptions for FY 2013–2015:

1. Broadly speaking, the NOAO base program (“scope of work”) will not contract, and our base funding level will inflate at 3% per year, as shown in NSF AST budget tables released in February 2011. FY 2015 base funding is set to be the same as FY 2014, as directed by NSF AST to reflect the fact that the current cooperative agreement will be put out for competition during FY 2014.
2. The level of business and operational services that NOAO provides to external entities may fluctuate (up or down), but the financial impact will continue to be offset by revenues received. If the level of service provided is reduced, it will not be reduced in any area to the point where it hurts the NOAO core capabilities. *The Appendix A budget tables do **not** show estimated revenue for base programs, but implicitly assume such revenue will continue at approximately the same level with appropriate inflation.*
3. In regard to item 2 above, NOAO assumes that revenue from NSO for services provided by NOAO will remain unchanged for this planning period, as it seems unlikely that NSO will complete its relocation during this period.
4. NOAO should be able to design and deliver one 4-m-class instrument every three to four years. *The cost of this activity is carried in the NSTC System Instrumentation budget line.*
5. NOAO will **not** be able to develop more complex and/or large-scale instruments without supplementary funding from NSF AST.
6. Assuming LSST construction begins in FY 2014, it should be possible to redirect at least \$1M per year in base funding from LSST to System instrumentation development in FY 2014 and FY 2015. *This shift is reflected in the NSTC System Instrumentation and LSST Project lines.* By keeping it within NSTC, the impact of further LSST delay is minimal financially, but of course this prevents NOAO from funding a different activity (e.g., another instrument, technology post-docs, etc.)
7. If other supplementary funding can be provided by NSF AST, NOAO desires to execute the following list of projects with or without partners (the list is not complete or prioritized):
 - a. Tucson main building renovation (east wing expansion)

- b. La Serena main building renovation
- c. Gemini spectrograph (ALTAIR)

*Estimates of required supplementary funding for these projects have **not** been included in the attached tables.*

7.4 Assumed Funding in Current Cooperative Agreement vs. Reality

On the second page of the Appendix A budget tables, the NOAO funding profile established in the 2009 cooperative agreement (CA) is compared to the current prediction of the actual funding profile. In summary, predicted base funding is at least \$1M per year below the CA funding profile (i.e., in *each* year). This is a significant reduction and **will** prevent NOAO from achieving all goals and objectives established in the CA, such as creating new programs for graduate students and post-docs in instrumentation development areas. Some level of review and prioritization of the CA requirements is necessary by NOAO over the next 12 months in coordination with the AURA OC and NSF PRP.

8 NOAO Tenant Observatories (April 2011)

Tenant	Location	Institutions
Arizona Radio Observatory (12-m)	Kitt Peak	U. of Arizona
Bok (2.3-m)	Kitt Peak	U. of Arizona, Arizona State U., Northern Arizona U.
Burrell Schmidt Telescope	Kitt Peak	Case Western Reserve U.
Calypso Observatory (1.2-m)	Kitt Peak	LSST, Inc. (33 member institutions)
Curtis Schmidt Telescope	Cerro Tololo	U. of Michigan
Gemini South (8.2-m)	Cerro Pachón	Argentina, Australia, Brazil, Canada, UK, USA
Global Oscillation Network Group (GONG), Cerro Tololo Station	Cerro Tololo	National Solar Observatory
Kitt Peak Visitor Center (0.5-m, 0.4-m, Solar, 0.4-m)	Kitt Peak	Kitt Peak National Observatory
Large Synoptic Survey Telescope (under construction)	Cerro Pachón	LSST, Inc (33 member institutions)
Las Cumbres Observatory Global Network (LCOGTN), Cerro Tololo Station	Cerro Tololo	LCOGT
McMath-Pierce Solar Telescope (2-m, 0.9-mEast, 0.9-mWest)	Kitt Peak	National Solar Observatory
MDM Observatory (2.4-m, 1.3-m)	Kitt Peak	Columbia U., Dartmouth College, U. of Michigan, The Ohio State U., Ohio U.
Panchromatic Robotic Optical Monitoring and Polarimetry Telescopes (PROMPT)	Cerro Tololo	U. of North Carolina
RCT Observatory	Kitt Peak	Planetary Science Institute, Western Kentucky U., So. Carolina State U., Villanova U., Fayetteville State U.
SARA-North (0.9-m)	Kitt Peak	Southeastern Association for Research in Astronomy (Florida Institute of Technology, East Tennessee State U., Florida International U., Valdosta State U., Clemson U., Ball State U., Agnes Scott College, U. of Alabama, Valparaiso U., Butler U.

NOAO Long-Range Plan 2011

Tenant	Location	Institutions
SARA-South (0.6-m)	Cerro Tololo	See above
SMARTS (1.5-m, 1.3-m, 1.0-m, 0.9-m)	Cerro Tololo	American Museum of Natural History, U. of Delaware, Georgia State U., NOAO, The Ohio State U., STScI, SUNY Stony Brook, Vanderbilt U., Yale U.
SOLIS	Kitt Peak	National Solar Observatory
Southern Observatory for Astronomical Research (SOAR) (4.1-m)	Cerro Pachón	Brazil, NOAO, U. of North Carolina, Michigan State U.
Spacewatch (1.8-m, 0.9-m)	Kitt Peak	U. of Arizona
Super-LOTIS (Livermore Optical Transient Imaging System)	Kitt Peak	U. of Arizona, Lawrence Livermore National Laboratory, NASA GSFC, Clemson U., UC Berkeley
Very Long Baseline Array, Kitt Peak Station	Kitt Peak	National Radio Astronomy Observatory
Wisconsin Hydrogen-Alpha Mapper (WHAM)	Cerro Tololo	Wisconsin-Madison
WIYN 0.9-m Observatory	Kitt Peak	Austin Peay State U., Haverford College, Indiana U., Rochester Institute of Technology, San Francisco State U., U. of Wisconsin-Madison, U. of Wisconsin-Oshkosh, U. of Wisconsin-Stevens Point, U. of Wisconsin-Whitewater, Wisconsin Space Grant Consortium
WIYN 3.5-m Observatory	Kitt Peak	U. of Wisconsin-Madison, Indiana U., Yale U., NOAO

9 Acronym List

Acronym	Definition
AAS	American Astronomical Society
ACCORD	AURA Coordinating Council of Observatory Research Directors
ALTAIR	Access to Large Telescopes for Astronomical Instruction and Research
AO	Adaptive Optics
AODP	Adaptive Optics Development Program
APP-11	Annual Program Plan FY 2011
Arcon	Array Controller (CCD controller developed at CTIO)
ARRA	American Recovery and Reinvestment Act of 2009
AST	Astronomical Sciences (Division of NSF)
ATST	Advanced Technology Solar Telescope
AURA	Association of Universities for Research in Astronomy
AURA-O	AURA Observatory in Chile
BOSS	Baryon Oscillation Spectroscopic Survey
CA	Cooperative agreement
CADIAS	Centro de Apoyo a la Didáctica de la Astronomía
CAS	Central Administrative Services
CASNET	Central Administrative Services Network (NOAO software application)
CCD	Charge-coupled Device
CCO	Chief Compliance Officer (NOAO)
CFO	Central Facility Operations
CIS	Computer Infrastructure Services
CNC	Computerized Numerical Control
COSMOS	CTIO Ohio State Multiple Object Spectrograph
CTIO	Cerro Tololo Inter-American Observatory
CXO	Chandra X-ray Observatory
DECam	Dark Energy Camera
DES	Dark Energy Survey
DOE	Department Of Energy
E2E	End-to-End
EC	Executive Committee
ELT	Extremely Large Telescope
EPO	Education and Public Outreach
ESO	European Southern Observatory

Acronym	Definition
ETS	Engineering and Technical Services
F&A	Facilities and Administrative
FITS	Flexible Image Transport System
FWHM	Full width half-maximum
FY	Fiscal Year
GALEX	Galaxy Evolution Explorer
Gbps	Gigabits per second
GHOS	Gemini High-resolution Optical Spectrograph
GK-12	grades Kindergarten through 12 th
GMT	Giant Magellan Telescope
GO-FAAR	Graduate Opportunities at Fisk in Astronomy and Astrophysics Research
GONG	Global Oscillation Network Group
GPI	Gemini Planet Imager
GSFC	Goddard Space Flight Center
GSMT	Giant Segmented Mirror Telescope
HBCU	Historically Black College/University
HR	Human Resources
HST	Hubble Space Telescope
HVAC	Heating, Ventilating, Air Conditioning
IQ	Image quality
IR	Infrared
IRAF	Image Reduction and Analysis Facility
IT	Information Technology
K-12	Kindergarten through 12 th grade
KOSMOS	Kitt Peak Ohio State Multi-object Spectrograph
KPNO	Kitt Peak National Observatory
KPVC	Kitt Peak Visitor Center
LBNL	Lawrence Berkeley National Laboratory
LBT	Large Binocular Telescope
LCOGTN	Las Cumbres Observatory Global Telescope Network
LRP	Long-Range Plan
LSP	Large Science Program
LSST	Large Synoptic Survey Telescope
LSSTC	Large Synoptic Survey Telescope Corporation
MMT	Multiple Mirror Telescope
MONSOON	(Not an acronym.) A scalable, multi-channel high-speed array controller

Acronym	Definition
	and image acquisition system
MPS	Mathematical and Physical Sciences (NSF division)
MREFC	Major Research Equipment and Facility Construction
NASA	National Aeronautics and Space Administration
NCSA	National Center for Supercomputing Applications
NDO	National Optical Astronomy Observatory's Director's Office
NEWFIRM	NOAO Extremely Wide-Field Infrared Imager
NN	NOAO North
NNFO	NOAO North Facility Operations
NOAO	National Optical Astronomy Observatory
NRAO	National Radio Astronomy Observatory
NS	NOAO South
NSA	NOAO South Administration
NSF	National Science Foundation
NSO	National Solar Observatory
NSSC	NOAO System Science Center
NSTC	NOAO System Technology Center
NWNH	New Worlds, New Horizons in Astronomy and Astrophysics
O/IR	Optical and Infrared
OC	Observatory Council
ODI	One Degree Imager
OMB	Office of Management and Budget (US)
OS	Office of Science
OSMOS	Ohio State MultiObject Spectrograph
OSTP	Office of Science and Technology Policy
P&T	promotion and tenure
PAARE	Partnerships in Astronomy & Astrophysics Research and Education
Pan-STARRS	Panoramic Survey Telescope & Rapid Response System
PI	Principal Investigator
POCA	A Partnership in Observational and Computational Astronomy
PRC	People's Republic of China
PROMPT	Panchromatic Robotic Optical Monitoring and Polarimetry Telescopes
PRP	Program Review Panel
RCR	Responsible Conduct in Research
ReSTAR	Renewing Small Telescopes for Astronomical Research
REU	Research Experiences for Undergraduates

Acronym	Definition
ROK	Republic of Korea
SAC	Science Advisory Committee
SAM	SOAR Adaptive-Optics Module
SARA	Southeastern Association for Research in Astronomy
SCD	System Community Development
SDM	Science Data Management
SDM-D	System Data Management Systems Development
SDM-O	System Data Management Systems Operations
SI	System Instrumentation
SIFS	SOAR Integral Field Unit Spectrograph
SMARTS	Small and Moderate Aperture Research Telescope System
SOAR	Southern Observatory for Astronomical Research
SOLIS	Synoptic Optical Long-Term Investigations of the Sun
SPIE	Society of Photo-optical Instrumentation Engineers
STELES	SOAR Telescope Echelle Spectrograph
STEM	Science, Technology, Engineering, and Math
STSci	Space Telescope Science Institute
SUS	System User Support
TAC	Time Allocation Committee
TBD	To be determined
TMT	Thirty Meter Telescope
TORRENT	(Not an acronym.) Next generation of MONSOON controller
TSIP	Telescope System Instrumentation Program
UC	University of California
UK	United Kingdom
US	United States of America
VAO	Virtual Astronomical Observatory
VoIP	Voice over Internet Protocol
WEBUD	Web-based Budget (NOAO software application)
WIYN	Consortium consisting of University of Wisconsin, Indiana University, Yale, and NOAO