

NATIONAL SOLAR OBSERVATORY (NSO)

\$21,140,000
-\$9,680,000 / -31.4%

National Solar Observatory Funding

(Dollars in Millions)

FY 2018 ¹ Actual	FY 2019 (TBD)	FY 2020 Request	Change over FY 2018 Request	
			Amount	Percent
\$30.82	-	\$21.14	-\$9.68	-31.4%

¹ The FY 2018 Actual includes \$3.50 million in additional FY 2018 one-time funding above the requested amount as well as \$8.0 million to forward fund part of the FY 2019 operations costs.

FY 2020 reflects the equilibrium level of the NSO budget commensurate with requirements to operate the Daniel K. Inouye Solar Telescope (DKIST), the construction of which is scheduled to be completed in June 2020. (See the MREFC chapter for more information). The FY 2020 Budget Request fully funds both the DKIST operations requirement (science operations and data center) and the NSO Integrated Synoptic Program (NISIP).

As a Federally Funded Research and Development Center, NSO is headquartered on the campus of the University of Colorado, Boulder and provides leadership to the solar community through management of the construction of DKIST. When completed, DKIST will be the world’s most powerful solar observatory. Life on Earth is critically dependent upon the Sun. Solar phenomena such as space weather (e.g. geomagnetic storms) can significantly impact our increasingly technological society. DKIST will investigate the structure and evolution of magnetic structures on the Sun on spatial scales of tens of kilometers, the fundamental length scales of the processes that drive space weather. With DKIST poised to answer fundamental questions in solar physics by providing transformative improvements over current ground-based facilities, solar research enabled by DKIST will benefit all of humankind. NSO also operates a coordinated worldwide network of six telescopes specifically designed to study solar oscillations. NSO routinely provides detailed synoptic solar data used by individual researchers and other government agencies through the NSO Digital Library. NSO data are also made available to the user community via the Virtual Solar Observatory.

In 2010, the National Academies of Science, Engineering, and Medicine (the National Academies) conducted its sixth decadal survey in astronomy and astrophysics. In their report, *New Worlds, New Horizons in Astronomy and Astrophysics*,¹ the National Academies committee recommended that “NSF-Astronomy should complete its next senior review before the mid-decade independent review that is recommended in this report, so as to determine which, if any, facilities NSF-AST should cease to support in order to release funds for (1) the construction and ongoing operation of new telescopes and instruments and (2) the science analysis needed to capitalize on the results from existing and future facilities.” In response to this recommendation, the MPS Division of Astronomical Sciences (AST) conducted a community-based review of its portfolio. The resulting Portfolio Review Committee (PRC) report, *Advancing Astronomy in the Coming Decade: Opportunities and Challenges*,² was released in August 2012 and included recommendations about all of the major AST telescope facilities.

Prior to receiving the PRC report, NSF had instructed NSO to begin divestment of the facilities on Kitt Peak, including the McMath-Pierce Solar Telescope and the Vacuum Tower (no longer in use), thereby accelerating the already-planned divestment by a few years. The PRC endorsed this decision. The PRC

¹ www.nap.edu/catalog.php?record_id=12951

² www.nsf.gov/mps/ast/ast_portfolio_review.jsp

recommended continued operation of the Dunn Solar Telescope (DST) at Sacramento Peak through 2017 and a 50.0 percent reduction in funding of NISP. The status of the transition of NSO-operated facilities is as follows:

- *McMath-Pierce Solar Telescope, Kitt Peak, AZ:* NSO ceased operating the McMath-Pierce Solar Telescope as a national user facility at the end of FY 2017. NSF completed a divestment options study of NSO facilities on Kitt Peak and initiated an environmental impact analysis process in FY 2018, consistent with the National Environmental Policy Act. In late FY 2018, NSF made a five-year award to the Kitt Peak National Observatory Visitor Center, part of NSF’s National Optical Astronomy Observatory, to repurpose the McMath-Pierce facility as an astronomy outreach and education center. This Windows on the Universe Center for Astronomy Outreach will highlight all of NSF’s research facilities related to astronomy and astrophysics.
- *Sacramento Peak Observatory, Sunspot, NM:* This facility includes the DST and associated infrastructure including office space, laboratory space, dining facilities, and housing. NSO ceased operating Sacramento Peak Observatory as a national user facility at the end of FY 2017. A proposal from New Mexico State University (NMSU) to transition operations of the facility from NSO to an NMSU-led consortium was funded in FY 2016. As discussions on the future of Sacramento Peak continued with NMSU, in parallel NSF began the preparation of an Environmental Impact Statement (EIS) in late 2016. Fully compliant with the National Environmental Policy Act, the final EIS was published in November 2018. The NSB gave its approval for the NSF Director (or her designee), at her discretion, to sign the Record of Decision (ROD) selecting Alternative 2: *Transition to Partial Operations by Interested Parties with Reduced NSF Funding*. Moving forward, a potential plan that would be consistent with Alternative 2 involves an NSF-NSO-NMSU partnership to operate the facility in a limited fashion. The ROD was signed in February 2019.
- *NSO Integrated Synoptic Program:* NISP consists of the Global Oscillations Network Group (GONG) and the Synoptic Optical Long-term Investigations of the Sun (SOLIS). GONG now has a component of its operations funding provided through a five-year (FY 2016–FY 2020) interagency agreement with the National Oceanic and Atmospheric Administration (NOAA). This NOAA funding supports the use of GONG and its data products for operational space weather forecasting. (Also see Partnerships section below). NSO is in the process of relocating the SOLIS facility to the Big Bear Solar Observatory (BBSO) on Big Bear Lake, CA.

Total Obligations for NSO

(Dollars in Millions)

	FY 2018	FY 2019	FY 2020	ESTIMATES ¹				
	Actual	(TBD)	Request	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
NSO Base Operations	\$5.06	-	\$3.83	\$3.94	\$4.06	\$4.19	\$4.31	\$4.31
NSO Education & Public Outreach	0.26	-	0.30	0.31	0.32	0.33	0.34	0.34
DKIST Operations ²	22.00	-	17.01	17.54	18.08	19.13	19.71	20.30
Facility Upgrades ³	3.50	-	-	-	-	-	-	-
Total	\$30.82	-	\$21.14	\$21.79	\$22.46	\$23.65	\$24.36	\$24.95

¹ Outyear funding estimates are for planning purposes only. The current cooperative agreement ends September 2024.

² Excludes funding for cultural mitigation activities in FY 2018 and FY 2020 as agreed to during the compliance process. The FY 2018 Actual includes \$8.0 million to forward fund FY 2019 operations. See the MREFC chapter for more information on DKIST.

³ The FY 2018 Actual includes \$3.50 million in additional FY 2018 one-time funding above the requested amount.

Facility Upgrades: In FY 2018, NSF awarded \$3.50 million for development of DKIST level 2 (advanced) data products, making DKIST data more accessible and usable to the solar research community.

Partnerships and Other Funding Sources: The managing organization for NSO is the Association of Universities for Research in Astronomy, Inc. (AURA), which comprises 46 U.S. member institutions and four international affiliate members. NSO partners include NOAA, the National Aeronautics and Space Administration, industrial entities, and universities and institutes that collaborate with NSO on solar instrumentation development. NSF is currently under discussions with New Mexico State University (NMSU) regarding future operations of Sacramento Peak Observatory and New Jersey Institute of Technology on future operations of SOLIS at BBSO.

Due to the increasing national and international awareness of the impacts of space weather on critical infrastructure and society in general, the importance of operational space weather forecasting has become apparent to U.S. policy makers. Space weather forecasting requires both accurate models of the heliospheric environment and precise observational data inputs to those models. NSO's GONG program provides operational data products on a routine basis that are used as inputs to predictive space weather models from the U.S. Air Force and the NOAA Space Weather Prediction Center. NSO is continuing the process of upgrading the GONG facility with \$2.50 million of funding provided in FY 2016, with the upgrade expected to be completed in FY 2019. NSF and NOAA are currently in the fourth year of a five-year interagency agreement whereby NOAA provides approximately \$800,000 per year in funding support for GONG operations.

NSO Base Operations, \$3.83 million: NSO Base Operations includes the offices at NSO's Boulder, Colorado headquarters and the world-wide NSO Integrated Synoptic Program consisting of the GONG array and the SOLIS telescope.

DKIST Operations, \$17.01 million: Support for DKIST operations is through the R&RA account, while DKIST construction support is through the MREFC account. (See the MREFC chapter for more information on construction.) The FY 2020 Budget Request for DKIST Operations represents the equilibrium level for the NSO budget commensurate with requirements to operate DKIST. This profile is funding the development of the DKIST science operations and data center in preparation for full DKIST operations, which is expected to begin in 2020.

Education and Public Outreach, \$300,000: NSO supports U.S. education goals by promoting public understanding and support of science and by providing education and training at all levels. NSO introduces undergraduate students to scientific research by providing stimulating environments for basic astronomical research and related technologies through NSF's separately funded Research Experiences for Undergraduates program. NSO has diverse education programs, including teacher training and curriculum development, and a newly-redesigned web portal.³

Management and Oversight

- **NSF Structure:** NSF oversight is handled by a program officer in AST working cooperatively with staff from MPS, BFA, the Office of the General Counsel, and the Office of Legislative and Public Affairs. Within BFA, the Large Facilities Office provides advice to program staff and assists with agency oversight and assurance. Representatives from some of the above NSF offices comprise the recently-chartered NSO Integrated Program Team, which meets on a semi-annual basis to discuss outstanding program issues. The MPS Facilities team, together with the NSF Chief Officer for Research Facilities (CORF), also provide high-level guidance, support, and oversight.
- **External Structure:** AURA is the managing organization for NSO. The NSO director reports to the president of AURA, who is the principal investigator on the current NSF cooperative agreement. AURA receives management advice from its Solar Observatory Council, composed of members of its scientific and management communities. NSO utilizes a users committee for the purposes of self-evaluation and

³ www.nso.edu

prioritization. The users committee, composed of scientists with considerable experience with the observatory, reviews for the NSO director all aspects of NSO that affect user experiences.

Reviews:

- NSF conducts regular reviews of NSO's Annual Progress Report and Program Plan (APRPP). The most recent APRPP review was held in February 2018 with the next scheduled review to occur March 2019.
- NSF periodically conducts Business Systems Reviews covering both the managing organization, AURA, and the center, NSO. The most recent BSR ended in March 2016, and AURA successfully implemented report recommendations and resolved outstanding issues.
- In Q3 FY 2019 a comprehensive midterm review of NSO's long-range plan for the second five years of the cooperative support agreement (CSA) will be conducted. Results of this review will be reported to the NSB.
- NSO also participates in reviews of the DKIST project. Recent reviews include: an Independent Risk Assessment conducted by the NSF Large Facilities Office (September–December 2017), a GAO assessment of "NSF Major Projects" (November 2017–June 2018), and an incurred cost audit (August 2018–present). In addition, a comprehensive external programmatic review and an Earned Value Management (EVM) system surveillance are planned for early Q3 FY 2019. These DKIST related reviews are described in the DKIST narrative in the MREFC chapter.

Renewal/Recompetition/Termination

In August 2014, the NSB authorized a renewed cooperative agreement with AURA for management and operation of NSO. The renewal award was put into place in June 2015 and will run through September 2024.