NATIONAL RADIO ASTRONOMY OBSERVATORY $76,340,000
-$5,150,000 / -6.3%

National Radio Astronomy Observatory

(Dollars in Millions)

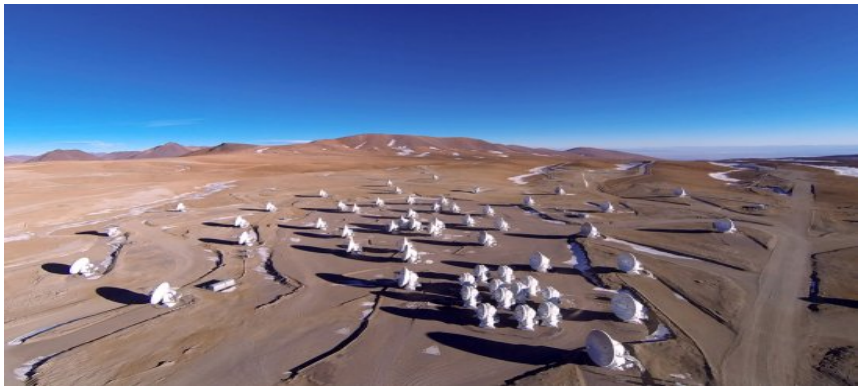
FY 2016 Actual[1]	FY 2017 (TBD)	FY 2018 Request	Change over FY 2016 Actual Amount	Change over FY 2016 Actual Percent
$81.50	-	$76.34	-5.16	-6.3%

[1] Includes $2.11 million provided by the MPS Office of Multidisciplinary Activities for expenses associated with the separation of the Green Bank Observatory and Very Long Baseline Array from NRAO and ALMA.

The National Radio Astronomy Observatory (NRAO) conceives, designs, builds, operates, and maintains state-of-the-art radio telescopes used by scientists from around the world. Operating synergistically with optical, infrared, and x-ray telescopes, NRAO facilities enable discovery over a remarkably broad range of key problems in modern astrophysics that reach from within our solar system to the most distant galaxies in the universe. Using NRAO observing capabilities and data archives, scientists: carry out precision cosmological measurements; test fundamental physics; probe deep into the earliest, most intense, and optically obscured phases of planet, star, galaxy, and black hole formation; reveal the cool gas from which stars form; provide essential tools for studying magnetic fields and high-energy cosmic phenomena; and seek to detect gravitational waves.

As a Federally Funded Research and Development Center headquartered in Charlottesville, Virginia, NRAO operates the Karl G. Jansky Very Large Array (VLA) near Socorro, New Mexico and is also the North American implementing organization for the international Atacama Large Millimeter/submillimeter Array (ALMA). These ground-based observing facilities for radio astronomy are available to any qualified researcher, regardless of affiliation or nationality, on the basis of scientific, merit-reviewed proposals. NRAO facilities annually serve over 2,500 users worldwide; moreover, growing demand for ALMA has resulted in the most proposals ever received for an astronomical facility in response to a single proposal call. NSF does not provide individual investigator awards targeted specifically for use of NRAO facilities, but many users are supported through NSF or NASA grants to pursue scientific programs that require use of NRAO facilities.

Including the ALMA operations staff located at NRAO, staff in FY 2018 will consist of 296 full-time equivalent positions (FTEs) in the operations and maintenance components: 105 in telescope operations, 60 in science support and research, 36 in development programs, 51 in computing and data management, 25 in administrative services, and 19 in education and public outreach. These numbers exclude staff at the partitioned GBT and VLBA telescopes which will be managed and operated separately from NRAO as well as 94 staff in the NRAO common cost pool which provides services to multiple observatories. In addition, the NRAO managing



ALMA is in science operations following the completion of construction in 2015. An international partnership between North America, Europe, and East Asia, ALMA provides orders-of-magnitude improvement in observing sensitivity and image quality over previous facilities. *Credit: NRAO/AUI.*

organization, Associated Universities, Inc. (AUI), employs local ALMA operations staff in Chile, currently consisting of approximately 237 FTEs.

Total Obligations for NRAO

(Dollars in Millions)

	FY 2016 Actual	FY 2017 (TBD)	FY 2018 Request	ESTIMATES[1] FY 2019	FY 2020	FY 2021	FY 2022	FY 2023
Operations & Maintenance	$43.84	-	$32.86	$33.95	$34.97	$36.02	$37.10	$38.22
Telescope Operations	*16.16*	-	*11.19*	*11.09*	*10.92*	*11.25*	*11.59*	*11.94*
Development	*3.30*	-	*3.37*	*3.94*	*4.56*	*4.70*	*4.84*	*4.99*
Science Operations	*4.72*	-	*6.19*	*6.40*	*6.59*	*6.79*	*6.99*	*7.20*
Administrative Services	*14.39*	-	*9.42*	*9.74*	*10.04*	*10.33*	*10.64*	*10.96*
Directors Office	*2.41*	-	*2.03*	*2.10*	*2.16*	*2.23*	*2.30*	*2.36*
Education and Public Outreach	*0.75*	-	*0.66*	*0.68*	*0.70*	*0.72*	*0.74*	*0.77*
NRAO/GBO/VLBA separation expenses	*2.11*	-	-	-	-	-	-	-
ALMA Operations	37.66	-	43.48	45.88	47.26	48.68	50.14	51.64
Total, NRAO	**$81.50**	**-**	**$76.34**	**$79.83**	**$82.23**	**$84.70**	**$87.24**	**$89.86**

[1] Outyear funding estimates are for planning purposes only. The current cooperative agreement ends in FY 2026.

The FY 2018 Budget Request for NRAO is below the FY 2016 Actual due to the partitioning of the Green Bank Observatory (GBO) and Very Long Baseline Array (VLBA) from NRAO, and because of funding carried over from the previous award which ended in FY 2016. GBO and VLBA are presented in the "Other Astronomical Facilities" narrative in the Facilities chapter of this document. Due to the favorable exchange rate and fuel prices in Chile, the FY 2016 Actual for ALMA Operations was below the FY 2016 Budget Request and the FY 2018 Budget Request is below the estimate for steady state funding.

Partnerships and Other Funding Sources: NRAO supplements AST support with funding provided by other NSF sources, other federal agencies, and non-federal sources. In FY 2016, NRAO received approximately $2.25 million from non-AST sources at NSF, $1.70 million from other federal agencies, and $4.52 million from U.S. universities, foreign scientific and technical institutes, and other non-federal and industrial sources. The development of new telescopes, instrumentation, and sensor techniques is conducted in partnership with relevant industries through competitive sub-awards to various large and small aerospace companies, radio antenna manufacturing firms, and specialized electronics and computer hardware and software companies.

Telescope operations, $11.19 million: This encompasses support for direct telescope and array operations of the VLA including maintenance, infrastructure upgrades, and telescope management.

Development, $3.37 million: Development programs include next generation electronics and detectors for radio astronomy, making fundamental contributions to materials science, the physics of quantum detectors, electromagnetics, photonics, and radio propagation.

Science operations, $6.19 million: This area includes telescope time allocation, staff research, science training and education, and science community outreach.

Administrative services, $9.42 million: This includes internal common costs used to allocate common and management expenses across the total pool of observatory activity, such as business services, utilities, and other facility costs at the operating locations, observatory management, and the library.

Director's office, $2.03 million: This supports the director's office and managing organization costs.

Education and Public Outreach, $660,000: NRAO supports a comprehensive outreach program that makes information about radio astronomy available to the public.[21] With over 150 students involved per year, NRAO facilities are used by graduate students carrying out dissertation research and work experience programs and by undergraduate students participating in the Research Experiences for Undergraduates (REU) program. NRAO also supports a visitor and education center and conducts active educational and public outreach programs. The VLA visitor center attracts over 20,000 public visitors each year.

ALMA Operations, $43.48 million: In FY 2015, NRAO completed construction of the international ALMA Observatory, funded through the Major Research Equipment and Facilities Construction (MREFC) account. Early operations funding for ALMA began in FY 2005 and ramps up to steady state operations in FY 2018. Operations funding supports a share of observatory operations in Chile, a technical development program, and the North American ALMA Science Center (NAASC). NRAO created the NAASC in 2006 to provide technical and scientific support for, and easy access by, the broad astronomical community that uses ALMA. The NAASC also organizes summer schools, workshops, and courses in techniques of millimeter and submillimeter astronomy.

Management and Oversight

- NSF Structure: In consultation with community representatives, a dedicated AST program officer carries out continuing oversight and assessment for NRAO and ALMA by making use of detailed annual program plans, long-range plans, quarterly technical and financial reports, and annual reports submitted to NSF. The AST program officer participates in the international ALMA Board and attends AUI/NRAO governance and advisory committee meetings. To address issues as they arise, AST works closely with other NSF offices, such as the Office of General Counsel, the Office of International Science and Engineering, the Division of Acquisition and Cooperative Support, and the Large Facilities Office in the Office of Budget, Finance, and Award Management.
- External Structure: Management is through a cooperative agreement with AUI. AUI manages the observatory through its own community-based oversight and users committees. The NRAO director reports to the president of AUI. Oversight of the international ALMA project is vested in the ALMA Board, which includes a member from NSF; coordination and management of the merged international efforts are the responsibility of the Joint ALMA Observatory (JAO) whose staff includes an ALMA director. An international ALMA review committee advises the ALMA Board.
- Reviews: NSF conducts annual reviews of the NRAO Program Operating Plan and strategic planning documents, ALMA operations, and the AUI Management Report. A Business Systems Review was conducted in FY 2012.

Renewal/Competition/Termination

Following a solicitation issued in FY 2014 (NSF 14-568), management and operation of NRAO, including ALMA, was competed and the National Science Board authorized a cooperative agreement with AUI for the period October 1, 2016 through September 30, 2026.

[21] https://public.nrao.edu/