

NATIONAL RADIO ASTRONOMY OBSERVATORY (NRAO)

\$79,130,000
+\$2,470,000 / 3.2%

National Radio Astronomy Observatory Funding
 (Dollars in Millions)

FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over	
			FY 2017 Actual Amount	Percent
\$76.66	-	\$79.13	\$2.47	3.2%

This table aggregates funding requested for NRAO and ALMA base operations.

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, x-ray, and gravitational wave 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 the sources of 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, continuing high 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 2019 will consist of 296 full-time equivalent positions (FTEs) in the operations and maintenance components: 114 in telescope operations, 56 in science support and research, 35 in development programs, 51 in computing and data management, 21 in administrative services, and 19 in education and public outreach. These numbers exclude staff at the partitioned Green Bank Observatory and Long Baseline Observatory, managed and operated separately from



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.*

NRAO, as well as 86 staff in the NRAO common cost pool that serve multiple observatories. In addition, the NRAO managing organization, Associated Universities, Inc. (AUI), employs local ALMA operations staff in Chile, currently about 254 FTEs.

Total Obligations for NRAO
(Dollars in Millions)

	FY 2017	FY 2018	FY 2019	ESTIMATES ¹				
	Actual	(TBD)	Request	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
Operations & Maintenance	\$31.67	-	\$38.85	\$34.97	\$36.02	\$37.10	\$38.22	\$36.36
<i>Telescope Operations</i>	10.63	-	10.99	10.92	11.25	11.59	11.94	10.82
<i>Development</i>	3.26	-	8.02	4.56	4.70	4.84	4.99	4.52
<i>Science Operations</i>	6.00	-	6.17	6.59	6.79	6.99	7.20	6.51
<i>Administrative Services</i>	9.15	-	10.49	10.04	10.33	10.64	10.96	11.29
<i>Directors Office</i>	1.99	-	2.42	2.16	2.23	2.30	2.36	2.43
<i>Education and Public Outreach</i>	0.64	-	0.76	0.70	0.72	0.74	0.77	0.79
ALMA Operations	44.98	-	40.28	47.26	48.68	50.14	51.64	56.19
Total	\$76.66	-	\$79.13	\$82.23	\$84.70	\$87.24	\$89.86	\$92.55

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

The total FY 2019 NRAO Budget Request includes ALMA operations (\$40.28 million) and non-ALMA operations and maintenance (\$38.85 million). The ALMA request provides for continued ALMA operations and is below the previously planned request due to the favorable exchange rate, lower fuel prices in Chile, and contributions from international partners.

Partnerships and Other Funding Sources: NRAO supplements NSF Division of Astronomical Sciences (AST) support with funding provided by other NSF sources, other federal agencies, and non-federal sources. In FY 2017, NRAO received approximately \$100,000 from non-AST sources at NSF, \$1.20 million from other federal agencies, and \$1.20 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, \$10.99 million: This encompasses support for direct telescope and array operations of the VLA including maintenance, infrastructure upgrades, and telescope management.

Development, \$8.02 million: The FY 2019 Budget Request continues to support development programs including next generation electronics and detectors for radio astronomy, as well as planning and the development of technologies for a next-generation centimeter wavelength facility (next generation Very Large Array, or ngVLA).

Science operations, \$6.17 million: This includes telescope time allocation, staff research, science training and education, and science community outreach.

Administrative services, \$10.49 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, \$2.42 million: This supports the director's office and managing organization costs.

Major Multi-User Research Facilities

Education and Public Outreach, \$760,000: NRAO supports a comprehensive outreach program that makes radio astronomy information available to the public.²⁴ With over 150 students involved per year, NRAO facilities are used by graduate students carrying out dissertation research and work experience programs and by undergraduates participating in the Research Experiences for Undergraduates 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, \$40.28 million: In FY 2015, NRAO completed construction of the international ALMA Observatory, funded through the 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, an 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. This 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 BFA.
- **External Structure:** Management is through a cooperative agreement with AUI, which manages the observatory through its own community-based oversight and users committees. The NRAO director reports to the AUI president. 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 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.

Renewal/Recompetition/Termination

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

²⁴ <https://public.nrao.edu/>