

ARECIBO OBSERVATORY (ARECIBO)

\$3,000,000
-\$16,220,000 / -84.4%

Arecibo Observatory Funding
(Dollars in Millions)

FY 2019 Actual ¹	FY 2020 (TBD)	FY 2021 Request	Change over FY 2019 Actual	
			Amount	Percent
\$19.22	-	\$3.00	-\$16.22	-84.4%

¹ Includes \$12.30 million in supplemental appropriation funding for hurricane repairs and \$2.03 million for continuity of operations into FY 2020. It excludes \$2.69 million of FY 2019 O&M costs obligated in FY 2018.

The Arecibo Observatory is a center for multidisciplinary research and education with advanced observational facilities. The observatory’s principal facility is one of the world’s largest single-dish radio/radar telescopes, a 305-meter diameter reflector located near the town of Arecibo in western Puerto Rico on approximately 140 acres of U.S. Government-owned land. Arecibo is currently operated and managed by the University of Central Florida (UCF) and subrecipients, Yang Enterprises, Inc. (YEI) and Universidad Ana G. Méndez (formerly Universidad Metropolitana), under a cooperative agreement with NSF that began on April 1, 2018. The observatory serves over 350 users annually with a wide range of research and observing instrumentation in passive radio astronomy, solar system radar astronomy, and space and atmospheric sciences. A peer-review telescope allocation committee provides merit-based telescope time to users. The committee is common to the three fields, but specific subject matter experts from outside the observatory are consulted for reviews. NSF does not provide awards targeted specifically for use of Arecibo, although some Arecibo users are supported through NSF or NASA grants to pursue scientific programs that require use of the facility. For example, NSF awarded \$5.80 million in 2018 to Brigham Young University for the development and deployment of an Advanced Cryogenic L-Band Phased Array Camera for Arecibo (ALPACA). With 40 beams, ALPACA will supersede the successful Arecibo L-band Feed Array (ALFA) 7-beam receiver installed at Arecibo in 2004, increasing the survey speed by a factor of five.

On September 20, 2017, Arecibo, along with the entire island of Puerto Rico, was severely impacted by Hurricane Maria. Damages were incurred by the physical infrastructure and the scientific equipment, including a broken 430 MHz line feed and some destroyed panels on the main reflector surface. Basic science operations (planetary radar and radio astronomy) restarted within weeks of the storm, at reduced and degraded performance levels. Funding for Arecibo repairs was provided in the Further Additional Supplemental Appropriations for Disaster Relief Requirements Act of 2018 (P.L. 115-123) totaling \$16.30 million. Of the total provided, \$14.30 million was identified for Arecibo of which \$2.0 million was disbursed in FY 2018, for the most critical immediate concerns including debris cleanup. An award for the remaining \$12.30 million for more complex repairs was made in FY 2019. The remaining repairs will take up to four years, carefully planned to prioritize the most critical structural repairs and to minimize impact to ongoing regular scientific observations. While scientific observations have been ongoing actively since late fall 2017, Arecibo does continue to operate at reduced and degraded performance. For example the overall sensitivity is reduced because the main reflector alignment is not yet complete and the 430 MHz line feed has not yet been repaired. The completion of the remaining repairs should bring Arecibo back to pre-hurricane performance levels.

Total Obligations for Arecibo
(Dollars in Millions)

	FY 2019	FY 2020	FY 2021	ESTIMATES ²				
	Actual ¹	(TBD)	Request	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026
Operations & Maintenance (MPS)	\$2.48	-	\$1.50	\$1.13	\$1.00	\$1.00	\$1.00	\$1.00
Operations & Maintenance (GEO)	4.44	-	1.50	1.13	1.00	1.00	1.00	1.00
Hurricane-related Repairs ³	12.30	-	-	-	-	-	-	-
Total	\$19.22	-	\$3.00	\$2.25	\$2.00	\$2.00	\$2.00	\$2.00

¹ Includes \$530,000 in MPS and \$1.50 million in GEO for continuity of operations into FY 2020. It excludes \$2.69 million of FY 2019 O&M costs obligated in FY 2018.

² Outyear funding estimates are for planning purposes only. The current cooperative agreement ends in March 2023.

³ Further Additional Supplemental Appropriations for Disaster Relief Requirements Act of 2018 (P.L. 115-123) provided NSF \$16.30 million to repair radio observatory facilities damaged by hurricanes that occurred during 2017. Of the total amount provided, \$14.30 million was identified for Arecibo. \$2.0 million was obligated in FY 2018, and the remaining \$12.30 million was obligated in FY 2019 to fund repairs over a four-year period.

For information on continuity of operations funding, see the opening narrative of this chapter.

Arecibo is jointly supported by the MPS Division of Astronomical Sciences (AST) and the GEO Division of Atmospheric and Geospace Sciences (AGS). An external review of the AST portfolio was completed in 2012, and an external review of the AGS Geospace Section portfolio was completed in 2016.

In 2012, the AST Portfolio Review Committee recommended “continued AST involvement in Arecibo be re-evaluated later in the decade in light of the science opportunities and budget forecasts at that time.”¹ The National Academies of Sciences, Engineering, and Medicine’s (the National Academies’) August 2016 report, *New Worlds, New Horizons: A Midterm Assessment*, reinforced this, with Recommendation 3.1 noting: “The NSF should proceed with divestment from ground-based facilities that have a lower scientific impact.”²

The Geospace Section (GS) Portfolio Review Committee was charged by the NSF Advisory Committee for Geosciences to review the most promising Geospace science strategies and critical capabilities and to reconcile these with the science goals described by the 2013 Decadal Survey for Solar and Space Physics.³ The GS is in AGS and its portfolio includes grant programs in upper-atmospheric sciences, the near earth space environment, sun-earth interactions, and space weather. This GS portfolio review⁴ was carried out using the assumption of an inflation-adjusted, flat budget for GS over the next decade to FY 2026. The GS Portfolio Review Committee recommendations included the reduction of annual AGS Arecibo funding from \$4.10 million to \$1.10 million by 2020.

GEO commissioned a review from a second panel assembled by the National Academies that assessed the process by which the GS Portfolio Review Committee reached its findings and recommendations. The panel published the results of this review⁵ in early 2017 and, for Arecibo, reiterated the recommendations of the GS Portfolio Review Committee.

Alongside scientific community reviews, NSF undertook a comprehensive environmental review of the potential operational changes. This process was formally concluded in November 2017, when NSF published a Record of Decision documenting its choice to collaborate with interested parties to maintain science-focused operations at Arecibo with reduced agency funding.

¹ www.nsf.gov/mps/ast/ast_portfolio_review.jsp

² www.nap.edu/catalog/23560/new-worlds-new-horizons-a-midterm-assessment

³ www.nap.edu/catalog/13060/solar-and-space-physics-a-science-for-a-technological-society

⁴ www.nsf.gov/geo/adgeo/geospace-review/geospace-portfolio-review-final-rpt-2016.pdf

⁵ www.nap.edu/catalog/24666/assessment-of-the-national-science-foundations-2015-geospace-portfolio-review

Major Multi-User Research Facilities

NSF issued a solicitation in January 2017 requesting proposals to provide continued operations and management of Arecibo for five years at reduced funding. The planned NSF funding profile presented in the solicitation gradually tapered NSF support to \$2.0 million by the fifth year of the award. In February 2018, NSF announced an award to University of Central Florida (UCF) to undertake formal transition activities for operations and management responsibilities for Arecibo in a cooperative agreement with NSF. The award continues science-focused operations that will maintain Arecibo's existing research lines of atmospheric, planetary, and astronomical research and continue its education and public outreach efforts. UCF has ongoing plans to secure partnerships and other funding sources for the operation and management of Arecibo. NSF is supporting UCF in these efforts and in the meantime has maintained steady support for Arecibo, rather than beginning the gradual tapering. The requested FY 2021 budget assumes new partnerships will be obtained, keeping Arecibo's overall budget for operations and management at the level necessary for full scientific operations.

Arecibo supplements NSF support with funding provided by other federal and non-federal sources. Since FY 2010, the NASA Near Earth Object Observation Program has committed \$2.0 million annually to Arecibo for the planetary radar program; this increased to \$3.60 million for FY 2013, with more observing time allocated to the NASA program. In FY 2020 and FY 2021, annual NASA support is expected to be approximately \$4.65 million. UCF continues to actively seek other partnerships and funding sources.

Education and public outreach continues to be an area of emphasis. Arecibo hosts a Research Experiences for Undergraduates (REU) site, and Ph.D. students receive training through the use of the facility. Over 360 students have participated in REU programs at Arecibo. Arecibo also sponsors a major outreach program in Puerto Rico via the Angel Ramos Foundation Visitor Center as well as summer workshops for K-12 teachers. This center attracts more than 80,000 visitors each year; over 1.5 million people have visited since its opening in 1997. Approximately 25 percent of these visitors are K-12 students. There was a downturn in visitors immediately following the 2017 hurricanes, but as the island recovered the number of visitors began to return to the expected rates each month. Exhibits at the visitor center were updated, and physical renovations to the visitor center building were completed in FY 2016. These improvements were funded by the Angel Ramos Foundation and the Ana G. Méndez University System and were formally approved by NSF. With funds received from the Puerto Rico Department of Education, Arecibo has hosted numerous teacher workshops and has trained approximately 500 teachers. This program integrates formal activities at the Angel Ramos Foundation Visitor Center into the STEM curriculum in Puerto Rico. Arecibo also hosts several meetings each year within a wide variety of scientific disciplines.



An image of the Arecibo Radio Telescope in Puerto Rico. The platform suspension structure, including the Gregorian dome that houses the main suite of research instruments, is visible over the 305-meter primary reflector dish below. The 96-foot line feed hanging to the left of the Gregorian dome was broken off during Hurricane Maria into several pieces, also damaging the dish below. Repairs are underway. *Credit: Arecibo Observatory/NSF.*

Operations and Maintenance: Arecibo administers observing time to the astronomy and aeronomy communities via competitive observing proposals and conducts educational and public outreach programs at all levels. Observing hours among science programs are allocated based on the quality of proposals. About 75 percent of astronomy users conduct their observing remotely via networked control software, while radar observations typically employ on-site users.

Management and Oversight

- **Funding:** AST funding will maintain basic operations costs and science programs in passive radio astronomy. AGS funding will support basic operations costs and science programs in aeronomy and space physics, including space weather.
- **NSF Structure:** The lead NSF program officer in AST, in close cooperation with a program officer in AGS, and in consultation with community representatives, provide ongoing oversight. The program officers make use of detailed annual program plans, long-range plans, quarterly technical and financial reports, and annual reports submitted by the management and operations awardee. They also attend awardee governance committee meetings, as appropriate. To address issues as they arise, program officers work closely with other NSF offices such as the Office of the General Counsel and the Division of Acquisition and Cooperative Support and the Large Facilities Office in BFA. The MPS facilities team and the Chief Officer for Research Facilities, also provide high-level guidance, support, and oversight. AST and AGS program officers conduct periodic site visits and frequent, regular teleconferences with the managing awardee.
- **External Structure:** Management is via a cooperative agreement. In February 2018 NSF announced an award to UCF to undertake formal transition activities leading to UCF assumption of full operations and management responsibilities for Arecibo. The transition to UCF's management occurred on April 1, 2018. UCF has two sub-awardees: YEI for engineering staff and facilities management and the Universidad Ana G. Méndez for management of the visitor's center and the education and public outreach efforts.
- **Reviews:** In January 2017, NSF issued a solicitation requesting proposals to provide continued operations and management of Arecibo for five years, but at reduced funding. Proposals received in response to this solicitation were afforded extensive NSF internal review together with formal review by a panel of external experts in observatory management and operations. Additionally, AST and AGS jointly conduct annual external reviews of Arecibo program plans. The next formal annual external review of UCF's management is scheduled to take place in Spring 2020.

Renewal/Recompetition/Termination

The current cooperative agreement with UCF for the management of Arecibo was awarded in April 2018, when UCF succeeded the previous managing organization. This followed a competitive process for a new five-year cooperative agreement, consistent with NSB policy. This agreement is in effect through March 2023.