

**OTHER ASTRONOMICAL FACILITIES**

**\$11,850,000**  
**+\$400,000 / 3.5%**

**Other Astronomical Facilities Funding**

(Dollars in Millions)

FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over	
			FY 2017 Actual Amount	Percent
\$11.45	-	\$11.85	\$0.40	3.5%

Other Astronomical Facilities consist of Green Bank Observatory (GBO) and Long Baseline Observatory (LBO). Prior to FY 2017, the National Radio Astronomy Observatory (NRAO) operated major radio telescopes at GBO in Green Bank, West Virginia, including the Robert C. Byrd Green Bank Telescope (GBT), and at 10 telescope array sites spanning the U.S. from the Virgin Islands to Hawai‘i, together constituting the Very Long Baseline Array (VLBA). Beginning in FY 2017, GBO and VLBA were separated from NRAO. GBO now operates GBT, and the newly formed LBO operates VLBA. Associated Universities, Inc. (AUI) remains the managing organization for GBO and LBO through a cooperative agreement with NSF. This narrative presents the combined FY 2019 Budget Request for GBO and LBO.

GBO provides key ground-based radio-wavelength research facilities for the US national community, while carrying out a program in education for public visitors and students. The GBT is the world’s largest fully steerable radio telescope and is GBO’s flagship research instrument. From fundamental physics and astronomy to the discovery and characterization of interstellar organic molecules that provide insight to the organic chemistry of life on Earth, to the search for intelligent life beyond the Earth, the GBO contributes to a very broad area of scientific research. GBO is also the anchor and administrative site of the 13,000-square-mile National Radio Quiet Zone, where all radio transmissions are limited. Having telescopes within this quiet zone allows for detection of faint scientific signals that would otherwise be drowned-out by human-made signals.

LBO operates the Very Long Baseline Array (VLBA), the world’s premier radio interferometer, using 10 identical 25-meter radio telescopes located across the U.S., from Hawaii to St. Croix Virgin Islands. The VLBA provides researchers with key insight into the structure and evolution of our galaxy, the Milky Way, and helps to determine the fundamental distance scale of the universe. In addition to basic astrophysical research, LBO contributes to the national infrastructure through the U.S. Naval Observatory’s use of the VLBA for measuring daily Earth Orientation parameters, necessary to maintain the integrity of the GPS system. In September 2017, the VLBA antenna at St. Croix, Virgin Islands sustained a direct hit from Hurricane Maria. Although significant damage was sustained across the island of St. Croix, preliminary reports indicate that the VLBA antenna on St. Croix escaped serious damage. The power is now up and running. An expert team is expected to visit the site in February to assess when operations may resume. Funding for full repair of the St. Croix installation are provided in the Bipartisan Budget Act of 2018.

In 2010, the National Academies conducted their sixth decadal survey in astronomy and astrophysics. In their report, *New Worlds, New Horizons in Astronomy and Astrophysics*,<sup>27</sup> the 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

<sup>27</sup> [www.nap.edu/catalog.php?record\\_id=12951](http://www.nap.edu/catalog.php?record_id=12951)

*Major Multi-User Research Facilities*

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 report, *Advancing Astronomy in the Coming Decade: Opportunities and Challenges*,<sup>28</sup> was released in August 2012 and included recommendations about all major AST telescope facilities.

In 2012, under constrained budgets, the Portfolio Review Committee recommended divestment of GBT and VLBA from AST funding because of a less compelling mapping to the science questions of the 2010 decadal survey compared to other facilities. As announced in a Dear Colleague Letter, NSF 13-074,<sup>29</sup> NSF partitioned GBT and VLBA from the competition for NRAO management and operations, which increased flexibility for exploring cost-efficient operational models and sustainable partnerships for GBO (comprising GBT and the Green Bank site and facilities) and VLBA. Existing partnerships are described below, and additional partner discussions with governmental and non-governmental entities are ongoing.

In FY 2016, AST received a proposal from AUI to continue management and operation of GBO and LBO in FY 2017 and FY 2018, separate from the management and operation of NRAO. Previously, the obligations for GBO and VLBA were heavily matrixed and not separable from the overall obligation for NRAO. Hence, GBO and VLBA, which were previously included in the NRAO narrative, were first presented as stand-alone entities in the FY 2017 Budget Request. The table below does not separate funding for GBO and LBO, as the detailed breakdown between the two depends on anticipated and achieved partnerships. Notional funding beyond FY 2020 is shown below, although it is expected that the outyear numbers will change significantly as partnerships evolve.

In FY 2017, pursuant to the National Environmental Policy Act, NSF began a formal environmental review of GBO to develop an Environmental Impact Statement (EIS), which will consider the environmental impact of various future alternatives for GBO. The process is expected to conclude in FY 2019 with publication of the final EIS, followed by a decision on the future path of the GBO, memorialized in a Record of Decision to be published by the NSF.

**Total Obligations for Other Astronomical Facilities**

(Dollars in Millions)

	FY 2017	FY 2018	FY 2019	ESTIMATES <sup>1</sup>				
	Actual	(TBD)	Request	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
Operations & Maintenance	\$11.45	-	\$11.85	\$11.85	\$11.85	\$11.85	\$11.85	\$11.85

<sup>1</sup> Outyear funding estimates are for planning purposes only. The current cooperative agreement runs through September 2018 and is expected to be extended through September 2019.

**GBO and LBO Operations and Maintenance, \$11.85 million:** This encompasses support for direct telescope operations at GBO and LBO, including maintenance, infrastructure upgrades, and telescope management as well as funds allocated for Education and Public Outreach.

**Partnerships and Other Funding Sources:** In FY 2017, GBO and LBO received approximately \$8.80 million from other sources, roughly half from non-federal partners and half from other federal sources. External (non-NSF) contributions represented approximately 25 percent of the total operations budget of GBO and over 50 percent of the total operations budget of LBO. Many of the GBO and LBO partnerships involve guaranteed allocations of observing time on GBT or VLBA.

In FY 2016, GBO began a 10-year partnership with Breakthrough Listen and had funding partnerships with

<sup>28</sup> [www.nsf.gov/mps/ast/ast\\_portfolio\\_review.jsp](http://www.nsf.gov/mps/ast/ast_portfolio_review.jsp)

<sup>29</sup> <http://nsf.gov/pubs/2013/nsf13074/nsf13074.jsp>

West Virginia University and the North American Nanohertz Observatory for Gravitational Waves (NANOGrav) consortium that are expected to continue through FY 2019. (The NANOGrav funding comes from the NSF award to the NANOGrav Physics Frontiers Center.) In addition, the GBO partnership with the RadioAstron space mission continues in FY 2018 and is anticipated to continue in FY 2019. Other partner discussions are ongoing.

In FY 2017, NSF and LBO established an agreement with the U.S. Naval Observatory to provide observing time and data in exchange for substantial support of LBO operations.

### **Management and Oversight**

- **NSF Structure:** In consultation with community representatives, a dedicated AST program officer carries out continuing oversight and assessment for GBO and LBO by making use of detailed annual program plans, technical and financial reports, and annual reports submitted to NSF. The AST program officer attends AUI 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 observatories through its own community-based oversight and users committees. The GBO and LBO directors report directly to the AUI Vice President for Radio Astronomy.
- **Reviews:** NSF conducts annual reviews of the Program Operating Plan and reports.

### **Renewal/Recompetition/Termination**

GBO and LBO are currently supported through a cooperative agreement, which ends on September 30, 2018. NSF expects to extend the current agreement to continue support of GBO through September 30, 2019. Management of GBO after FY 2019 will be based on the further development of collaboration opportunities, the EIS process mentioned previously, and a potential solicitation. As for LBO, NSF expects to receive a proposal from AUI that will help to identify the future structure and operational support required for LBO and the VLBA beyond FY 2018.