

**GEMINI OBSERVATORY (GEMINI)**

**\$20,280,000**  
**-\$13,740,000 / -40.4%**

**Gemini Observatory Funding**

(Dollars in Millions)

FY 2018 Actual <sup>1</sup>	FY 2019 (TBD)	FY 2020 Request	Change over FY 2018 Actual	
			Amount	Percent
\$34.02	-	\$20.28	-\$13.74	-40.4%

<sup>1</sup> FY 2018 Actual includes \$13.0 million in additional FY 2018 one-time funding above the requested amount.

The Gemini Observatory consists of twin optical/infrared eight-meter telescopes, one each in the northern and southern hemispheres, thereby providing complete coverage of the sky. Gemini North sits atop Maunakea, Hawai’i at an elevation of 4,200 meters, while Gemini South is located on the 2,700-meter summit of Cerro Pachón, Chile. Both telescopes offer a suite of modern optical and infrared instrumentation and employ sophisticated adaptive optics technology to compensate for the blurring effects of the Earth’s atmosphere.

Among the fundamental questions being investigated at Gemini are those pertaining to the age and rate of expansion of the universe, the origin of the “dark energy” that drives cosmic acceleration, the nature of non-luminous matter, the processes that give rise to the formation and evolving structures of galaxies, and the birth of stars and their planetary systems. Technological advances incorporated into the design of the two telescopes optimize their imaging capabilities and infrared performance as well as their ability to quickly swap instruments in response to changing atmospheric conditions. Gemini’s flexible observing modes make it ideal for reacting rapidly to opportunities that arise in the new era of multi-messenger astronomy. Gemini is also developing software and hardware aimed at enhancing its ability to respond to the expected growth in demand for observations needed to characterize objects discovered by NSF facilities like the Large Synoptic Survey Telescope (LSST), the Laser Interferometer Gravitational-Wave Observatory (LIGO), and the IceCube Neutrino Observatory.

The research agencies that currently form the Gemini international partnership include: NSF; the National Research Council of Canada; the Ministério da Ciência, Tecnologia e Inovação of Brazil; the Ministerio de Ciencia, Tecnología e Innovación Productiva of Argentina; the Comisión Nacional de Investigación Científica y Tecnológica of Chile; and the Korea Astronomy and Space Science Institute of South Korea, which joined the partnership in July 2018. These six agencies are signatories to the Gemini International Agreement, which currently covers January 2016 through December 2021. Renewal of this agreement beyond 2021 is currently under negotiation, with all participants expressing their intentions to remain in the partnership.

Gemini helps educate astronomy and engineering students through undergraduate internship programs in both Hawai’i and Chile. Gemini also provides an engaging focal point for public outreach and student training in all of the partner countries. Gemini-sponsored activities attract students and teachers at all levels of elementary through high school education. The unique Gemini-led *Journey Through the Universe* program in Hilo, Hawai’i (now in its 15<sup>th</sup> year) and its sister activity, *Viaje al Universo* in La Serena, Chile, bring astronomy into the classroom through week-long annual events that involve dozens of astronomers from Gemini as well as from many of the other astronomical facilities at each location. Gemini staff also provide guidance and support to the ‘Imiloa Astronomy Center, a public facility in Hilo that seeks to advance the integration of science and indigenous culture through education.

The observatory supports four facility-class instruments at each telescope as well as a vigorous visiting instrument program. Each telescope is equipped with adaptive optics and laser guide star systems which greatly improve the ability to correct for atmospheric blurring. The unique Multi-Conjugate Adaptive Optics (MCAO) system on Gemini South provides near-infrared images that are often sharper than those observed from space, covering a field-of-view on the sky that is wider than any competing system on the ground. With support from NSF, the observatory is developing a similar capability for Gemini North. Together, these two MCAO systems will provide the Gemini community with this unique capability over both hemispheres.



The Gemini South telescope in Chile firing its laser into the night sky (left). The laser produces a “constellation” of five synthetic guide stars (center) that are used to correct for atmospheric blurring. The Gemini observation (on the right) of a Globular Cluster shows an example of an image sharpened in this way. *Credit: Gemini Observatory/NSF/AURA.*

The observatory is developing a number of new imagers and spectrometers. Instrument development is funded by the partners as a portion (typically 10 percent) of their annual operations contributions. These instrumentation funds are currently being used to build the Gemini High-resolution Optical SpecTrograph (GHOST), a workhorse instrument for studying a vast array of astronomical objects, and an eight-beam optical/infrared spectrograph known as SCORPIO. SCORPIO will be used to characterize exotic transient phenomena discovered with LSST, LIGO, and other time-domain facilities in the 2020s. Two other major instruments are being designed and built by Gemini partners: the Gemini InfraRed Multi-Object Spectrograph, GIRMOS (Canada), and a successor to a hugely popular visiting instrument, the Immersion GRating INfrared Spectrograph, IGRINS (South Korea and the United States). Together these four instruments will greatly enhance Gemini’s capabilities well into the next decade, ensuring the observatory stays at the forefront of astronomical research in all areas.

Construction of the telescopes and their instrumentation involved a large number of industrial entities in several countries, with areas of specialization that included large and complex optical systems, engineering, electronics, electro-mechanical systems, and computing. Continued development in these areas is reflected in the instrumentation and facilities renewal activities that are incorporated into the overall budget.

The U.S. share of Gemini Observatory observing time is open to proposals from any researcher in the U.S. astronomical community, with peer-review committees providing merit-based telescope time. NSF does not provide awards targeted specifically for the use of Gemini, although U.S. users are often supported through separate NSF research awards to pursue scientific programs that require the use of the observatory. In a typical year, approximately 600 unique observing programs are submitted to Gemini, 70 percent of which are from U.S.-based astronomers.

## Major Multi-User Research Facilities

In the FY 2020 Budget Request, NSF plans to maintain full operations of Gemini Observatory through the entire fiscal year. The Budget Request of \$20.28 million includes the full contribution of the NSF (U.S.) share of facility operations costs. Due to recently provided funding for facility upgrades, the requested budget does not include any NSF (U.S.) contribution to the Gemini Instrument Development Fund (IDF), which is obtained through partner contributions that typically have been 10.0 percent of annual operations contributions in recent years.

### Total Obligations for Gemini (Dollars in Millions)

	FY 2018	FY 2019	FY 2020	ESTIMATES <sup>1</sup>				
	Actual	(TBD)	Request	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
Operations & Maintenance	\$21.02	-	\$20.28	\$22.98	\$23.67	\$23.67	\$23.67	\$23.67
Facility Upgrades <sup>2</sup>	13.00	-	-	-	-	-	-	-
<b>Total</b>	<b>\$34.02</b>	<b>-</b>	<b>\$20.28</b>	<b>\$22.98</b>	<b>\$23.67</b>	<b>\$23.67</b>	<b>\$23.67</b>	<b>\$23.67</b>

<sup>1</sup> Outyear funding estimates are for planning purposes only. The current cooperative agreement ends December 2022.

<sup>2</sup> FY 2018 Actual includes \$13.0 million in additional FY 2018 one-time funding above the requested

Facility Upgrades: In FY 2018, NSF awarded \$13.0 million for support of three related projects: (1) the development of a state-of-the-art MCAO system for Gemini North, (2) software improvements needed to optimize Gemini's capability for rapid time-domain follow-up of transient sources and alerts for multi-messenger astronomy (MMA), and (3) public information and outreach activities focused on MMA.

### Management and Oversight

- **Governance Structure:** The observatory is governed by the Gemini Board, which was established by the Gemini International Agreement signed by the six participating agencies mentioned above. This board meets at least twice a year and acts as the primary forum for interactions and decisions among the participants in the Gemini Agreement; the Gemini Board ensures that Gemini is managed and operated in accordance with the Agreement and is the body with overall budgetary and policy control over the observatory. The Gemini Board is supported by two sub-committees, the Gemini Finance Committee (GFC) and the Gemini Science and Technology Advisory Committee (STAC). NSF serves as the Executive Agency for the partnership, carrying out the project on their behalf. The United States holds six of the 14 seats on the Gemini Board; NSF appoints the five non-NSF U.S. members.
- **Managing Organization:** The Gemini Observatory is currently managed by the Association of Universities for Research in Astronomy, Inc. (AURA) on behalf of the partnership through a cooperative agreement with NSF. The current cooperative agreement covers January 2017 to December 2022. AURA conducts its own management reviews through oversight committees.
- **NSF Structure:** NSF has one seat on the Gemini Board, currently occupied by the AST program officer responsible for Gemini programmatic oversight. Another NSF staff member serves as Board executive secretary. The program officer monitors operations and development activities at the observatory, nominates U.S. scientists to Gemini advisory committees, conducts reviews on behalf of the partnership, participates in various Board sponsored sub-committees, and approves funding actions, reports, and contracts. The program officer is also currently the chair of the GFC. To address issues as they arise, AST has a dedicated Integrated Project Team (IPT) which includes representatives from other NSF offices, such as the Office of General Counsel, OISE, and the Division of Acquisition and Cooperative Support and the Large Facilities Office in BFA. The MPS Facilities team, together with the Chief Officer for Research Facilities (CORF), also provide high-level guidance, support, and oversight.
- **Reviews:** In addition to the oversight activities of the Gemini Board and its subcommittees, NSF conducts periodic reviews of the management and operation of the observatory, and of AURA's

financial systems. The IPT reviews quarterly operations, development, and financial plans, and also the observatory's annual progress report and program operations and development plan for the coming year. NSF conducted a Business System Review (BSR) of the observatory and AURA's centralized administrative services in 2013. In April 2017, NSF conducted a Gemini Accounting System Audit, and plans to conduct an Incurred Cost Audit of the Gemini cooperative agreement and a new BSR in 2019 or early 2020.

**Renewal/Recompetition/Termination**

The United Kingdom withdrew from the Gemini partnership at the end of 2012, resulting in about a 24 percent budget reduction for overall facility management and operations. More recently, Australia, a 6.3 percent partner in 2015, first moved to a limited-term collaboration and then ceased involvement entirely in late 2017. The Republic of Korea had a similar limited-term, year-to-year arrangement for a four-year period through the end of 2018, though has since become a full Participant in the Gemini International Agreement. With a 5.0 percent share, Korea has essentially replaced the loss in revenue incurred when Australia left the partnership. The current Agreement between the six Gemini Participants expires in December 2021. At a recent Assessment Point (November 2018), all Participants in the Agreement expressed their desire to remain in the partnership at current participation levels beyond December 2021. The details of a new Agreement are to be established over the next two to three years.

Re-competition of the management and operation of Gemini was last conducted in 2014-2015. The National Science Board authorized a new cooperative agreement with AURA in February 2016 that covers January 2017 through December 2022. Depending on the success of the National Center for Optical-Infrared Astronomy (see section on National Optical Astronomy Observatory in this chapter), NSF will determine in FY 2020 whether to re-compete the Gemini management, renew the cooperative agreement, or extend the cooperative agreement to facilitate its integration into the National Center for Optical-Infrared Astronomy and a future management competition.