

GEMINI OBSERVATORY (GEMINI)

\$21,660,000
-\$2,580,000 / -10.6%

Gemini Observatory Funding
(Dollars in Millions)

FY 2017 Actual ¹	FY 2018 (TBD)	FY 2019 Request	Change over	
			FY 2017 Actual Amount	Percent
\$24.24	-	\$21.66	-\$2.58	-10.6%

¹ Includes a one-time technical reobligation of \$3.74 million at the end of an expiring cooperative support agreement. Without this action, the change from FY 2017 to FY 2019 would be \$1.16 million or 5.7 percent.

The Gemini Observatory consists of twin optical/infrared 8-meter telescopes, one each in the northern and southern hemispheres, thereby providing complete coverage of the sky. Gemini North sits atop Mauna Kea, 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 superb image quality 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 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 was one of the first observatories used to characterize the recent neutron star merger/gravitational wave event GW170817, and also responded rapidly to the recently discovered interstellar asteroid A/2017 U1 whose orbit crossed the solar system in October 2017.

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; and the Comisión Nacional de Investigación Científica y Tecnológica of Chile. These five agencies are signatories to the Gemini International Agreement, which currently covers January 1, 2016 through December 31, 2021.

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 14th 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 provides 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 state-of-the-art adaptive optics and laser guide star systems which greatly improve the ability to correct for atmospheric blurring. The advanced multi-conjugate adaptive optics system on Gemini South continues to lead the world, providing near-infrared

images that are often sharper than those observed from space with smaller telescopes, and which cover a field-of-view on the sky that is wider than any competing system on the ground.

The observatory is actively developing new imagers and spectrometers. By agreement, the observatory partners contribute an additional amount (10 percent of their annual operations contribution) to the new instrument fund. The Gemini High-resolution Optical SpecTrograph (GHOST), a workhorse instrument for studying a vast array of astronomical objects, is nearing completion. A contract was signed in early 2017 for a new 8-beam optical/infrared spectrograph, OCTOCAM, that will be used to characterize exotic transient phenomena discovered with the Large Synoptic Survey Telescope (LSST) in the 2020s. This latest instrument selection directly responds to the need for an LSST follow-up instrument, as recommended in the 2012 NSF Division of Astronomical Sciences (AST) Portfolio Review report *Advancing Astronomy in the Coming Decade: Opportunities and Challenges*,¹⁴ in the 2015 National Academies report *Optimizing the U.S. Ground-Based Optical and Infrared System*,¹⁵ and in the 2016 KAVLI Futures Symposium report *Maximizing Science in the Era of LSST: A Community Based Study of Needed US OIR Capabilities*.¹⁶

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. However, U.S. users are often supported through separate NSF research awards to pursue scientific programs that require the use of the observatory.

Total Obligations for Gemini

(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 ²	\$24.24	-	\$21.66	\$22.31	\$22.98	\$23.67	\$23.67	\$23.67

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

² FY 2017 includes a one-time technical reobligation of \$3.74 million at the end of an expiring cooperative support agreement.

In the FY 2019 Budget Request, NSF plans to maintain full operations of Gemini Observatory through the entire fiscal year. The Budget Request of \$19.69 million includes the full contribution of the NSF (U.S.) share of facility operations costs. However, it does not include the \$1.97 million NSF (U.S.) contribution to the Gemini Instrument Development Fund, which is obtained through additional partner contributions of 10 percent of annual operations contributions, and is intended to support future instrument development, as agreed to in the Gemini partnership agreement.

Management and Oversight

- **Governance Structure:** The observatory is governed by the Gemini Board, which was established by the Gemini International Agreement signed by the participating agencies. 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. NSF

¹⁴ www.aura-astronomy.org/news/2012/ast_portfolio_review_report.pdf

¹⁵ www.nap.edu/catalog/21722/optimizing-the-us-ground-based-optical-and-infrared-astronomy-system

¹⁶ www.noao.edu/meetings/lsst-oir-study/

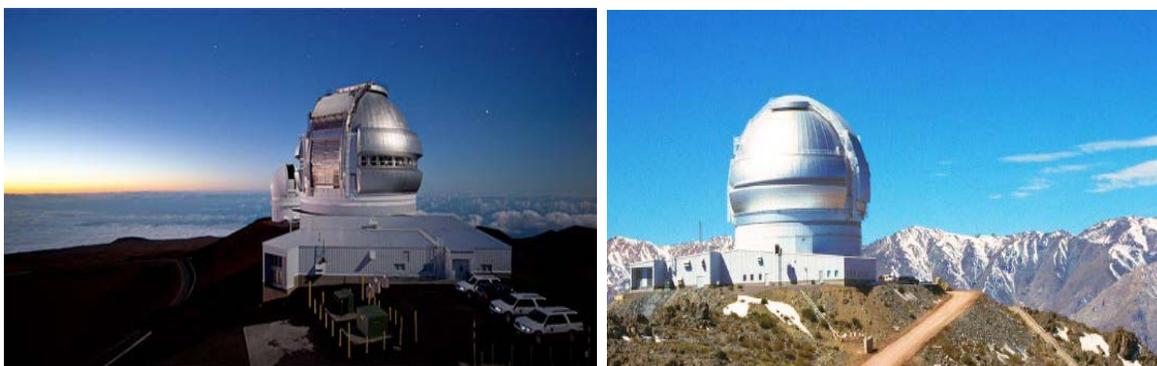
Major Multi-User Research Facilities

serves as the Executive Agency for the partnership, carrying out the project on their behalf. The U.S. holds six of the 13 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 1, 2017 to December 31, 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.
- **Reviews:** NSF conducts periodic reviews of the management and operation of the observatory, and of AURA's financial systems. NSF most recently 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 a new BSR in 2018 or 2019.

Renewal/Recompetition/Termination

The United Kingdom withdrew from the Gemini partnership at the end of 2012, requiring 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 participation and then ceased participation entirely in late 2017. South Korea has a similar limited-term, year-to-year arrangement through the end of 2018, though discussions are underway regarding full partnership from 2019 onwards at a roughly 5 percent level. The next participant assessment point is scheduled for 2018, at which time existing partners will establish participation levels in the Gemini Observatory beyond December 2021.



The Gemini telescopes atop Maunakea in Hawai'i (left) and Cerro Pachón in Chile (right). *Credit: Gemini Observatory*

The cooperative agreement for managing Gemini that expired at the end of 2016 included a plan to support the transition to the new operations model under the reduced budget due to changes in international partner participation. Reductions in project scope included a decreased facility-class instrument complement on each telescope, cost savings from a shift to remote telescope operations from the sea level base facilities in Hawai'i and Chile, a redesign of the data archive, and prioritization of serving the partner user communities over internal scientific research activities. These and other transition projects have now been successfully completed.

Prior to the completion of the aforementioned transition program, re-competition of the management and operation of Gemini was 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.