

GEMINI OBSERVATORY

\$21,030,000
+\$1,150,000 / 5.8%

Gemini Observatory

(Dollars in Millions)

FY 2016 Actual	FY 2017 (TBD)	FY 2018 Request	Change over FY 2016 Actual	
			Amount	Percent
\$19.88	-	\$21.03	\$1.15	5.8%

The Gemini Observatory consists of twin optical/infrared 8-meter telescopes, one each in the northern and southern hemispheres. Gemini North sits atop Mauna Kea, Hawaii at an elevation of 4,200 meters, while Gemini South is located on the 2,700-meter summit of Cerro Pachón, Chile. This siting of the two telescopes provides complete coverage of the sky and complements observations from space-based observatories. 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 issues being investigated by today's astronomers 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 formation of stars and their planetary systems. The current generation of large optical/infrared telescopes is central to these studies, owing to their unsurpassed sensitivity and exquisite spatial resolution. Technological advances incorporated into the design of the Gemini telescopes optimize their imaging capabilities and infrared performance as well as their ability to rapidly reconfigure the attached instrumentation in response to changing atmospheric conditions.

The national research agencies that currently form the Gemini international partnership include: NSF, the Canadian National Research Council (NRC), the Argentinean Ministerio de Ciencia, Tecnología e Innovación Productiva, the Brazilian Ministério da Ciência, Tecnologia e Inovação and the Chilean Comisión Nacional de Investigación Científica y Tecnológica (CONICYT). The five agencies are signatories to the Gemini International Agreement which covers all activities related to Gemini. The current Agreement covers the period January 1, 2016 through December 31, 2021.

The Gemini observatory helps educate astronomy and engineering students through undergraduate internship programs in both Hawaii 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, Hawaii (now in its 13th year) and its sister activity, *Viaje al Universo* in La Serena, Chile, bring astronomy into the classroom through a week-long annual event that involves dozens of astronomers from Gemini as well as from many of the other astronomical facilities at each location. Gemini staff members 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.

Laser guide star systems, which greatly improve the ability to correct for atmospheric blurring, are available at both facilities. The advanced multi-conjugate adaptive optics system on Gemini South continues to lead the world, providing near-infrared images that exceed the quality available from orbiting observatories, and which cover a field-of-view on the sky that is wider than any competing system. Over the next 12 months Gemini will be upgrading the lasers at both observatories to more powerful and more reliable devices.

Major Multi-User Research Facilities

The observatory is actively developing new imagers and spectrometers. The state-of-the-art Gemini Planet Imager, GPI, is now in regular use for directly imaging planets orbiting nearby stars; a new spectrograph, the Gemini High-resolution Optical SpecTrograph (GHOST), a workhorse instrument for studying a vast array of astronomical objects, is nearing completion; and a contract has just been signed 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* (discussed further below), in the 2015 National Academies report *Optimizing the U.S. Ground-Based Optical and Infrared System*, and in the 2016 KAVLI Futures Symposium report *Maximizing Science in the Era of LSST: A Community Based Study of Needed US OIR Capabilities*.

As noted earlier, the international partnership that operates Gemini currently consists of the U.S., Canada, Brazil, Argentina, and Chile, with the U.S. as the majority partner. Construction of the telescopes and their instrumentation involved a large number of industrial entities in these and other countries, with areas of specialization that included large and complex optical systems, engineering, electronics, electro-mechanical systems, and computing. Continued development in these technological 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 by any researcher in the U.S. astronomical community, with peer-review allocation 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.



The Gemini North Telescope atop Mauna Kea in Hawaii. In this long-exposure photograph, the stars in the night sky appear as arcs due to the rotation of the earth. The reddish “beams” emanating from the top of the Gemini dome are produced by the laser used to support the observatory’s adaptive optics system. As the laser is tracked across the sky, following the target being observed, its narrow beam appears smudged in this time-lapse photograph. *Credit: J. Pollard/Gemini Observatory*

Total Obligations for the Gemini Observatory

(Dollars in Millions)

	FY 2016 Actual	FY 2017 (TBD)	FY 2018 Request	ESTIMATES ¹				
				FY 2019	FY 2020	FY 2021	FY 2022	FY 2023
Operations & Maintenance	\$19.88	-	\$21.03	\$21.66	\$22.31	\$22.98	\$23.67	\$23.67

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

In 2010, the National Research Council (NRC) conducted its sixth decadal survey in astronomy and astrophysics. In their report, *New Worlds, New Horizons in Astronomy and Astrophysics*¹², the NRC committee recommended that NSF should complete a senior review before the mid-decade to determine which, if any, facilities 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 facilities”. In response to this recommendation, AST in the Directorate for Mathematical and Physical Sciences (MPS) conducted a community-based review of its portfolio. The resulting Portfolio Review Committee (PRC) report, *Advancing Astronomy in the Coming Decade: Opportunities and Challenges*¹³ released in August 2012, and included recommendations about all of the major AST telescope facilities.

The PRC report ranked Gemini Observatory as a critical component of our nation’s future astronomical research resources and recommended that the U.S. retain a majority share in the international partnership for at least the next several years. However, given the constraints that were considered, the Committee recommended that the maximum U.S. contribution to Gemini operations in 2017 and beyond should be \$17.0 million per year. Given the withdrawal of the United Kingdom and Australia from the Gemini partnership (see below), the NRC recommended that the U.S. increase its partner share in Gemini; therefore the FY 2018 Budget Request is higher than the amount recommended by the PRC.

The FY 2018 Request includes the full U.S. contribution to baseline operations at the level agreed to by the participants in the Gemini International Agreement (\$19.12 million in FY 2018), with an additional contribution of \$1.91 million to the Gemini Instrument Development Fund (equivalent to 10 percent of the operations contribution). Funding levels through FY 2021 have been agreed to by the current Gemini participants and are specified in a Gemini Board resolution from May 2015; the U.S. contributions provided for the out-years reflect a 3 percent increase per year for the period 2016-2021. No commitment has yet been made for FY 2022 and beyond, by any of the Gemini participants, though the FY 2022 figures denote a continuation of the 3 percent annual increase extended to the end of the current cooperative agreement.

Management and Oversight

- **External Structure:** The observatory is governed by the Gemini Board, which was established by the Gemini International Agreement signed by the participating agencies. NSF 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, and NSF appoints the five non-NSF members. The Board includes the director of the U.S. National Optical Astronomy Observatory (NOAO) in order to facilitate increased cooperation between NOAO and Gemini and to provide an improved voice for the general U.S. astronomical community. 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. AURA conducts its own management reviews through standing oversight committees.
- **NSF Structure:** NSF has one seat on the Gemini Board, currently occupied by the AST program officer

¹² www.nap.edu/catalog.php?record_id=12951

¹³ www.nsf.gov/mps/ast/ast_portfolio_review.jsp

Major Multi-User Research Facilities

responsible for Gemini programmatic oversight. An additional NSF staff member serves as the executive secretary to the board. 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 Gemini Board sponsored sub-committees, and approves funding actions, reports, and contracts. The program officer is also the current chair of the Gemini Finance Committee, a subcommittee of the Gemini Board that monitors and assesses the observatory's budget and provides guidance to the Gemini Board.

- Reviews: NSF conducts periodic reviews of the management and operation of the observatory, and of AURA's financial systems, often in collaboration with the Gemini Board. NSF has conducted Business System Reviews (BSRs) of the observatory and AURA's centralized administrative services in 2009 and 2013. In April 2017, NSF conducted a Gemini Accounting System Audit, and plans to conduct a new BSR in 2018.

Renewal/Competition/Termination

The United Kingdom withdrew from the Gemini partnership at the end of 2012 which required the observatory to adjust to an approximate 24 percent reduction in budget. More recently, Australia, a 6.3 percent partner in 2015, moved to a more limited participation on a year-to-year basis. South Korea has a similar arrangement (year-to-year) through the end of 2017, however, discussions with South Korea are currently underway regarding full partnership. The next participant assessment point is scheduled for 2018, at which time partners will establish their levels of participation in the Gemini Observatory beyond December 2021.

The recently expired (end of 2016) NSF cooperative agreement for managing the Gemini Observatory included a plan to negotiate the transition to the new operations model under the reduced budget described above. Reductions in project scope included a decreased instrument complement on each telescope, cost savings from a shift to remote telescope operations from the sea level base facilities in Hawaii and Chile, a redesign of the data archive, and a tighter focus on serving the partner user communities at the expense of internal scientific research activities. These and other transition projects have now been successfully completed.

Prior to the completion of the above transition program, recompetition of the management and operation of Gemini was conducted in 2014-2015. Proposals were solicited in August 2014 and received in February 2015. Face-to-face meetings between NSF and the proposing organizations in July 2015 supplemented an extensive review of these proposals by a panel of experts in April 2015. The National Science Board approved NSF's selection of AURA as the managing organization for the observatory in February 2016, under a new cooperative agreement that covers the period January 1, 2017 to December 31, 2022.