Atacama Large Millimeter Array $42,760,000

The FY 2010 Budget Request for the Atacama Large Millimeter Array (ALMA) is $42.76 million, which represents the ninth year of an eleven year project totaling an estimated $499.26 million.

Appropriated and Requested MREFC Funds for the Atacama Large Millimeter Array

(Dollars in Millions)

FY 2006[1] & Earlier	FY 2007	FY 2008	FY 2009	FY 2010 Request	FY 2011 Estimate	FY 2012 Estimate	Total
$190.97	$64.30	$102.07	$82.25	$42.76	$13.91	$3.00	$499.26

[1]An additional $31.99 million was appropriated through the MREFC account prior to FY 2005 for concept and development.

Baseline History: A $26.0 million, three-year Design and Development Phase was originally planned for a U.S.-only project, the Millimeter Array. NSF first requested funds for the design and development for this project in FY 1998. In June 1999, the U.S. entered into a partnership via a Memorandum of Understanding (MOU) with the European Southern Observatory (ESO), a consortium of European funding agencies and institutions. The MOU committed the partners to construct a 64 element array of 12 meter antennas. NSF received $26.0 million in appropriations between FY 1998 and FY 2000. Because of the expanded managerial and technical complexity of the joint U.S./ESO project, now called ALMA, an additional year of Design and Development was provided by Congress in FY 2001 at a level of $5.99 million. In FY 2002, $12.50 million was appropriated to initiate construction of ALMA; the U.S. share of the cost was estimated to be $344.0 million. The National Research Council (NRC) of Canada joined ALMA as a partner in 2003. In 2004, Japan entered under the provisions of a MOU between NSF, ESO, and the National Institute of Natural Sciences of Japan.

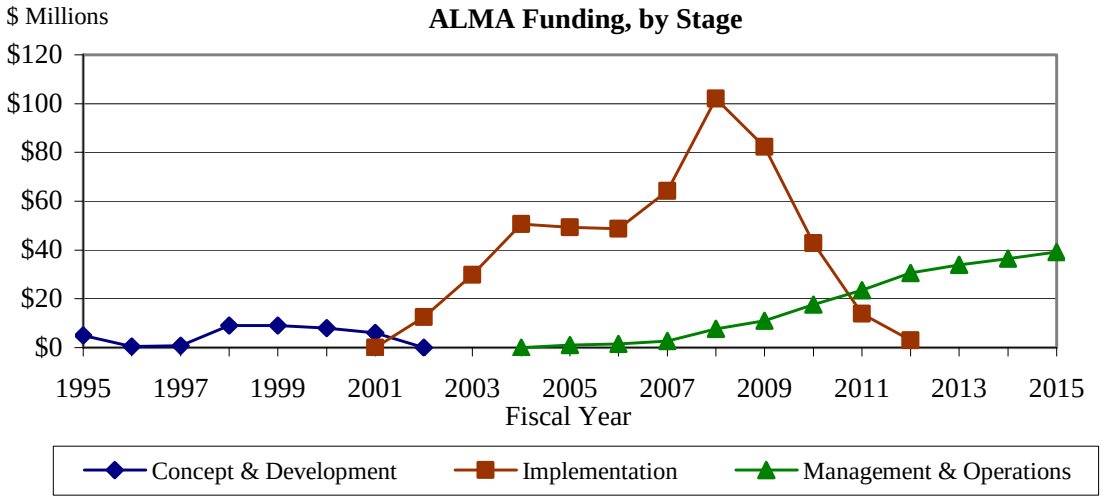
The ALMA Board initiated rebaselining in the fall of 2004 under the direction and oversight of the Joint ALMA Office (JAO) Project Manager. The project was at that point sufficiently mature that the baseline budget and schedule established in 2002, prior to the formation of the partnership, could be refined based on experience. The rebaselining process took approximately one year, scrutinizing cost and schedule throughout the project, assessing technical and managerial risk, and ultimately revising the assumptions on the scope of the project. The new baseline plan developed by the JAO assumed a 50-antenna array as opposed to the original number of 64, extended the project schedule by 24 months, and established a new U.S. total project cost of $499.26 million. The FY 2009 Request was increased by $7.50 million relative to the re-baselined profile in order to allow more strategic use of project contingency to buy down near-term risk, as recommended by the 2007 annual external review. The increase in FY 2009 was offset by a matching decrease in FY 2011.

The global ALMA project will be an aperture-synthesis radio telescope operating in the wavelength range from 3 to 0.4 mm. ALMA will be the world's most sensitive, highest resolution, millimeter-wavelength telescope, combining sub-arcsecond angular resolution with the sensitivity of a single antenna nearly 100 meters in diameter. The array will provide a testing ground for theories of planet formation, star birth and stellar evolution, galaxy formation and evolution, and the evolution of the universe itself. The interferometer is under construction at 5,000 meter altitude near San Pedro de Atacama in the Second Region of Chile, the ALMA host country.

Total Obligations for ALMA
(Dollars in Millions)

	Prior Years	FY 2008 Actual	FY 2009 Plan	FY 2010 Request	ESTIMATES FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
R&RA Obligations:									
Concept & Development	6.50	-	-	-	-	-	-	-	-
Management & Operations	6.21	7.64	11.00	17.57	23.50	30.65	33.92	36.41	39.17
Subtotal, R&RA Obligations	$12.71	$7.64	$11.00	$17.57	$23.50	$30.65	$33.92	$36.41	$39.17
MREFC Obligations:									
Concept & Development	31.99	-	-	-	-	-	-	-	-
Implementation	255.27	102.07	82.25	42.76	13.91	3.00	-	-	-
Subtotal, MREFC Obligations	$287.26	$102.07	$82.25	$42.76	$13.91	$3.00	-	-	-
Total: ALMA Obligations	**$299.97**	**$109.71**	**$93.25**	**$60.33**	**$37.41**	**$33.65**	**$33.92**	**$36.41**	**$39.17**

Totals may not add due to rounding.



Once completed, ALMA will function as the most capable imaging radio telescope ever built and will bring to millimeter and submillimeter astronomy the high-resolution aperture synthesis techniques of radio astronomy. ALMA will image at 1 millimeter wavelength with the same 0.1 arcsecond resolution achieved by the Hubble Space Telescope at visible wavelengths, and will form a critical complement to the leading-edge optical, infrared, ultraviolet, and x-ray astronomical instruments of the twenty-first century.

ALMA will help educate and train U.S. astronomy and engineering students; at least 15 percent of ALMA's approximately 1,000 yearly users are expected to be students. There is already substantial involvement by graduate students in applied physics and engineering at universities participating in the ALMA Design and Development program, providing an opportunity to broaden participation in science and engineering by members of under-represented groups.

Extensive public and student ALMA outreach programs will be implemented in North America, Europe, and Chile as ALMA approaches operational status. A visitors' center will be constructed at the 2,800

meter-altitude Operations Support Facility gateway to the ALMA site near San Pedro de Atacama in northern Chile. The project also supports a fund for the Antofagasta (II) Region of Chile that is used for economic, scientific, technical, social, and cultural development, particularly within the nearby towns of San Pedro de Atacama and Toconao.

The first Vertex antenna formally accepted by the ALMA Observatory at the site in Chile. *Credit ALMA/ESO/NAOJ/NRAO*

North America and Europe are equal partners in the core ALMA instrument. Japan joined ALMA as a third major partner in 2004, and will deliver a number of enhancements to the baseline instrument. The North American side of the project, consisting of the U.S., Canada and Taiwan, is led by Associated Universities Incorporated/National Radio Astronomy Observatory (AUI/NRAO). Funding and execution of the project in Europe is carried out through the European Southern Observatory (ESO). Funding of the project in Japan is carried out through the National Institutes of Natural Sciences of Japan and project execution is the responsibility of the National Astronomical Observatory of Japan.

From an industrial perspective, ALMA instrumentation will push gallium arsenide and indium phosphide transistor amplifier technology to high frequencies, will challenge production of high-density, high-speed integrated circuits for computational uses, and is expected to stimulate commercial device and communication technologies development.

Peer-review telescope allocation committees will provide merit-based telescope time but no financial support. NSF will not provide awards targeted specifically for use of ALMA. Most U.S. users will be supported through NSF or NASA grants to pursue research programs that require use of ALMA.

Construction progress continues in FY 2009, both at the site in Chile and within the ALMA partner countries. The most significant events for the project in FY 2008 were delivery of six production antennas to Chile, delivery of the two antenna transporters and installation of the first receiver system in an antenna. In FY 2010 the first antennas will be delivered to the final, high-altitude site and science commissioning will begin. Early science operations are expected to commence in FY 2011 and completion of the construction project and the start of full science operations are planned to occur around the end of FY 2012.

Project Report:

Management and Oversight:

- NSF Structure: Programmatic management is the responsibility of the ALMA Program Manager in the Division of Astronomical Sciences (AST) in the Directorate for Mathematical and Physical Sciences (MPS). An NSF advisory group consisting of representatives from the Office of General Counsel, the Office of Budget, Finance, and Award Management, the Office of International Science and Engineering, and the Office of Legislative and Public Affairs, serves as a standing ALMA Project Advisory Team (PAT). The NSF Deputy Director for Large Facility Projects (DDLFP) is a member of the PAT and provides advice and assistance.

- External Structure: An international ALMA Management Advisory Committee (AMAC) advises AST and the ALMA Board. Management of the NRAO effort on ALMA is carried out under a cooperative

agreement with AUI. Oversight of the full international project is vested in the ALMA Board, whose membership includes an NSF member; coordination and management of the merged international efforts is the responsibility of the Joint ALMA Office (JAO), whose staff includes the ALMA Director, Project Manager, and Project Engineer.

- Reviews:

  - Technical reviews: The JAO holds frequent technical and schedule reviews at appropriate design and fabrication milestones. For example, a series of reviews to assess the robustness and risks to the schedule was held in November 2008 through January 2009. Reviews of the regional centers that assemble and test receiver electronics are planned for FY 2009 and FY 2010. A function of the AMAC is to conduct project-wide external reviews and to audit internal reviews on behalf of the ALMA Board.
  - Management, Cost, and Schedule reviews: NSF, through the ALMA Board, holds external reviews of the broad Project and in targeted areas. A review of the Operations Plan was conducted in February 2007. A project-wide annual review, held in December 2008, assessed management, cost and schedule performance, status, issues, and risks. NSF also directly charges external assessments, both broad-based e.g. through its review of the performance of the managing organization (AUI), and of specific areas as warranted. For example, an external review of safety was held in October 2008. The project-wide annual reviews will continue and a science operations readiness review will be held in FY 2010.
  - Upcoming reviews: Receiver integration center operational readiness review in April 2009. Review of Chilean labor management performance in June 2009. Review of schedule and schedule drivers in July 2009. Annual External Reviews in November 2009 and late 2010. Operations review in 2010.

Current Project Status:

- Major project milestones attained in FY 2008 included:

  - Full acceptance and occupation of the technical building at the high-altitude site
  - Installation of the first quadrant of the digital correlator at the high site
  - Acceptance of the mid-level facilities including offices, warehouse, test and maintenance laboratories and control room
  - Delivery of the second through sixth North American antennas to Chile
  - Delivery of the two antenna transporters
  - Delivery of the first North American and East Asian receivers to Chile
  - Astronomical spectra obtained with the prototype antennas and test receivers at the antenna test facility in Socorro, New Mexico

- Major milestones for FY 2009 are expected to include:

  - Acceptance of the first North American and Japanese antennas
  - Continued delivery of North American antennas at a rate of one every two months.
  - Delivery of the first three European antennas to Chile
  - Delivery of the second quadrant of the correlator
  - Delivery of the third and fourth North American and East Asian receivers
  - Test interferometry at the mid-level facility in Chile using two antennas

- Major milestones for FY 2010 are expected to include:

  - Acceptance of the first European antennas
  - Continued delivery of North American antennas at a rate of one every two months.
  - Acceptance of the eighth through fourteenth North American antennas and the remaining three Japanese antennas
  - Transport of several antennas to the final, high-altitude site in Chile (may be very end of FY 2009)
  - Start of commissioning

Cost and Schedule:

The current schedule performance is slightly behind plan due to equipment delivery delays, in particular delivery of the first antennas and receivers. Consequently, the major milestones of early-science and full-science are forecast to be delayed by six to nine months although schedule recovery is possible. Cost performance is very good at this stage in the project – cost variance is -1 percent and schedule variance is -6 percent relative to the 2005 baseline – with approximately 40 percent contingency remaining in the uncommitted budget.

Risks:

- Full handover of the first North American and Japanese antennas will enable the other delivered antennas to be tested and accepted swiftly. The schedule for production of the European antennas should begin to stabilize once the first few antennas are delivered to Chile.
- While fabrication of the individual receiver components is making good progress, their integration into complete receiver systems and subsequent testing are the pacing items for the schedule and will be one of the key challenges for the project in the coming 12 months.
- The supply of 5MW of electricity to operate the full array has not been finalized due to the unstable power economy in Chile and South America. The original plan for gas-fed generators was eliminated following the cessation of gas exports from Bolivia and Argentina. Consequently, project management is pursuing alternative options of electricity supply via a 160km-long overhead line to the nearest grid access point or multi-fuel on-site power generation.
- For operations, the principal challenge is to ramp-up the staffing to 200 technically qualified personnel over the next two years.

Future Operations Costs:

Operations and maintenance funds phase in as initial site construction is completed and antennas begin to be delivered. Funds will be used to manage and support site and instrument maintenance, array operations in Chile, early science (FY 2011) and eventually full science operations, and in support of ALMA observations by the U.S. science community. Full ALMA science operations are anticipated to begin around the end of FY 2012. An Operations Plan and a proposal for North American operations were externally reviewed in FY 2007 and a funding profile through FY 2011 was authorized by the National Science Board in December 2007. The operations estimates for FY 2012 and beyond are based on current cost projections. The anticipated operational lifespan of this project is at least 30 years.