MAJOR SCIENTIFIC INSTRUMENTATION

	APPLICATION OF OPERATING RESOURCES							
	FEDERAL APPROPRIATIONS		GENERAL TRUST		DONOR/SPONSOR DESIGNATED		GOV'T GRANTS & CONTRACTS	
	FTE	$000	FTE	$000	FTE	$000	FTE	$000
FY 2006 ACTUAL	0	4,583	0	0	0	0	0	0
FY 2007 ESTIMATE	0	3,886	0	0	0	0	0	0
FY 2008 ESTIMATE	0	3,886	0	0	0	0	0	0

STRATEGIC GOAL: STRENGTHENED RESEARCH

Federal Resource Summary by Performance Objective and Program Category

Performance Objective/ Program Category	FY 2007		FY 2008		Change	
	FTE	$000	FTE	$000	FTE	$000
Strengthened Research						
Research						
Engage in research and discovery	0	3,886	0	3,886	0	0
Total	**0**	**3,886**	**0**	**3,886**	**0**	**0**

BACKGROUND AND CONTEXT

Smithsonian science is engaged in research and discovery focused on the origin and evolution of the universe, the formation and evolution of Earth and similar planets, the discovery and understanding of biological diversity, and the study of human diversity and cultural change.

To achieve the goal of Strengthened Research, the Smithsonian uses its multi-year funding from the Major Scientific Instrumentation (MSI) line item to develop large-scale instrumentation projects that enable scientists working at the Smithsonian Astrophysical Observatory (SAO) to expand the frontiers of astronomy and astrophysics research. The Smithsonian's criteria for selecting and proposing these projects are: 1) the instrumentation will enable compelling scientific advances that would not otherwise occur (either at SAO or *anywhere else in the world*) for some time to come; 2) the instrumentation is novel and technically advanced, and *would not be developed* without SAO's contribution; and 3) the

science enabled by the innovative instruments is consistent with the Smithsonian Institution's strategic plan, "Science Matters: Priorities and Strategies." The fundamental role for federal appropriations is to support the basic scientific infrastructure that enables SAO to conduct research, compete for external grants and funding, publish in peer-reviewed journals, and inform the public about the latest scientific discoveries in an exciting and compelling manner. Because of the magnitude of the costs and the time required to fabricate major new instruments and reconfigure existing ones, the Institution requests that funds for these projects be kept available until they are spent.

Three SAO projects are included in the MSI line item: an array of submillimeter telescopes (Submillimeter Telescope Array, or SMA) on Mauna Kea, Hawaii; instrumentation for the converted Multiple Mirror Telescope (MMT) at SAO's Fred L. Whipple Observatory on Mt. Hopkins, Arizona; and, with initial FY 2007 funding, the design and fabrication of the Giant Magellan Telescope (GMT) in northern Chile.

For FY 2008, the Institution is not seeking a funding increase for MSI.

MEANS AND STRATEGY

Submillimeter Telescope Array

The SMA, a collaborative project of SAO and the Academia Sinica Institute of Astronomy and Astrophysics in Taiwan, is made up of eight 20-foot-diameter antennas located on the summit of Mauna Kea, Hawaii, which function as one giant telescope. This facility operates at higher frequencies than those of any other major radio telescope, enabling scientists to probe in unprecedented detail the formation of new planets around other stars.

The SMA is now the most capable submillimeter observatory in the world. It can operate in three frequency bands, observing simultaneously in two of them. The 690 Gigahertz (GHz) receivers, operating at an unprecedented frequency (which is hundreds of times the frequencies used in television, cell phones, and WiFi systems), enable observations that have only been dreamed of before, and clearly illuminate the leadership position of those working with the SMA.

A Science Working Group has been developing a strategy to optimize the science return from the SMA. The recommendations of this group were presented to the SMA Advisory Committee in April 2005. The advisory

committee was very impressed with the achievements of the SMA projects, and endorsed a preliminary decision to mount a major observing campaign to study the region surrounding the super-massive black hole at the center of the Milky Way galaxy. This campaign achieved spectacular initial results with observations made in 2006.

FY 2007 funding is being used for two complementary purposes. First, SAO is implementing a phase-monitoring system, which will greatly expand upon the successes of previous high-frequency observations. Second, SAO is working on an entirely new, very powerful set of receivers for use in the range of 340–420 GHz.

FY 2008 base resources of $1,666,000 will be used to continue development of the phase-monitoring system and work on the receivers. In addition, SAO plans to expand the range of spatial scales that the SMA can probe. This will be accomplished by moving the antennas closer together than was previously possible (due to an ultra-compact array) and, more technically challenging, to receive data with the telescopes spread out to the maximum extent possible. The extended array will enable the SMA to resolve fine details in disks around other stars where astronomers believe planets are forming.

Multiple Mirror Telescope

The MMT, a joint project of SAO and the University of Arizona, dedicated in 1979, was made up of six identical 1.8-meter telescopes in a single altitude-azimuth (naval-gun-type) mount. The original multiple-mirror design provided a state-of-the-art solution to the technological limitation in casting large mirrors at that time. Following advances in mirror-casting technology developed by the University of Arizona, in the 1990s SAO replaced the six smaller mirrors of the original MMT with a single mirror 6.5 meters in diameter, thus more than doubling the light-gathering capability of the telescope and increasing its field of view some 400 times.

The converted MMT is an extremely powerful instrument. SAO's technical investments are producing outstanding scientific results. A major recent success is the discovery of hyper-velocity stars, which are leaving the Milky Way at huge speeds after a complicated collision with the massive black hole at the center of our galaxy.

The final instrument needed for the MMT is Binospec, an imaging spectrograph with dual 8'x15' fields of view and a very compact layout for excellent stability. Binospec will enable the study of large numbers of very faint objects. SAO scientists will use it to study the origin and evolution of

galaxies in the universe, and to characterize the elusive, pervasive dark energy of the cosmos. Currently, SAO is finishing Binospec's detailed design and preparing fabrication drawings for all components requiring long lead times to build.

With FY 2007 funding, SAO is completing drawings for the remaining components and placing orders for the main Binospec structure, the lens mounts for Binospec's optics, its mechanisms (e.g., slit-mask, filter, and grating exchangers, and a flexure compensation system), control electronics, wiring harnesses and cables, gratings, dewars, and charge-coupled devices. As parts arrive, SAO must immediately begin assembly and testing of major components.

FY 2008 base resources of $1,720,000 will be used to complete the major procurements and much of the fabrication. The instrumentation will be completed and tested on the telescope in FY 2009.

Giant Magellan Telescope

The GMT, planned to be an extremely large, next-generation, optical and infrared telescope, will be constructed at the Las Campanas Observatory in northern Chile by a consortium of nine universities and observatories, including SAO. The GMT will be made up of seven 8.4-meter primary mirrors, six of which will be off-axis and arranged in a floral pattern to produce a telescope with an effective aperture of 25.4 meters (83 feet). The GMT's innovative design and huge size will enable it to probe the secrets of planets that have formed around other stars in the Milky Way, explore the formation of black holes, peer back in time toward the Big Bang with unprecedented clarity, and delve into the nature of dark matter and dark energy. It will be capable of gathering five times more light than the world's largest existing telescope, and of producing images many times sharper than presently possible.

The development of the GMT is essential to SAO's future in observational optical and infrared astrophysics, and to the Smithsonian Institution's goal of pursuing scientific excellence in the study of the origin and nature of the universe. The Smithsonian Institution's Science Commission identified two broad research themes that are the focus of the GMT: the origin and nature of the universe and the formation and evolution of the Earth and similar planets. A GMT-class telescope is the top priority for new ground-based facilities in the most recent decadal study of astronomy and astrophysics conducted by the National Academy of Sciences.

In addition to SAO, the consortium developing this new telescope includes the Carnegie Observatories, Harvard University, University of Arizona, University of Michigan, Massachusetts Institute of Technology, University of Texas at Austin, Texas A&M University, and the Australian National University. The total capital cost of the GMT (estimated to be approximately $550 million in 2004 dollars) will be shared among the members of the consortium during the decade that it is expected to complete construction. Over a multi-year period, SAO wishes to contribute funding from the MSI line item toward the design and development of the GMT. The partners will raise the balance of the funds needed from private sources and from the National Science Foundation.

Currently, the GMT project is in the second year of its detailed engineering phase. FY 2007 and FY 2008 funding ($500,000) will enable SAO to support the continuing engineering design and development of the GMT. In future years, SAO intends to request additional funding under the MSI line item to support its share of costs as a member of the GMT consortium.

STRATEGIC GOALS AND FY 2008 ANNUAL PERFORMANCE GOALS

Strengthened Research

Engage in research and discovery focused on understanding the origin and evolution of the universe, Earth and planets, biological diversity, and human culture ($3,886,000)

- Continue developing and implementing the atmospheric phase-monitoring system and constructing the new receivers needed to expand the capabilities of SAO's SMA. This will enable the eight separate antennas to be operated jointly when they are located at their greatest separations (up to half a kilometer) and at the highest operating frequencies. When completed, the SMA will have the resolving power on the sky of a telescope half a kilometer in size, an unprecedented capability at short wavelengths. SAO scientists will be able to make previously impossible observations of the black hole at the center of the Milky Way, and of other solar systems in which planets are now forming
- Complete work on the spectacular new MMT instrument, Binospec, which will enable SAO scientists to conduct very efficient spectroscopic studies of very faint objects. SAO scientists will use this instrument to study the processes of galaxy formation, and to characterize the pervasive dark energy in the cosmos

- Continue the engineering design and development of the GMT. The future of ground-based astronomy depends on the next generation of very large telescopes that can extend the reach of science and the resolution of images from deep space. The consortium proposing to build the GMT has the best record of building large telescopes in a cost-effective manner. An independent Conceptual Design Review for GMT was completed in April 2006, and it endorsed the plans for this 25-meter class observatory. Continued MSI funding in FY 2008 and future years will enable SAO to continue supporting the engineering design and development of this telescope. The GMT will enable SAO scientists to study phenomena ranging from the properties of planets around other stars to the nature of dark energy in the cosmos