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Astronomy in the FY 2005 Budget

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HIGHLIGHTS

- The National Aeronautics and Space Administration's[1] (NASA) Office of Space Science[2] (OSS) would begin a redirection of its efforts to support the President's vision of sending humans to the Moon and ultimately to Mars under the FY 2005 budget. A new research line in OSS—Lunar Exploration (LE)—would begin in FY 2005 at a level of $70 million. LE aims to land a robotic test bed mission on the Moon by 2008 and send humans there as early as 2015. Other goals include developing architectures for future solar system exploration, conducting robotic missions to establish engineering and environmental conditions on the Moon in preparation for ultimate human landings, establishing a long-duration human presence on the Moon by 2020 as a stepping stone for future solar system exploration, and by 2015 demonstrating new human-robotic space operations and attendant supporting technologies.

- The National Science Foundation's (NSF[3]) division of Astronomical Sciences (AST[4]) budget would increase by 4 percent from $197 million in FY 2004 to $204 million in FY 2005 (see Table II-7). AST provides funding directly to astronomical researchers. Arguably one of the most important discoveries of our age was made with support from the NSF. Dr. Geoff Marcy and colleagues[5] used NSF support (as well as NASA and other institutions) to perfect a new observational technique and use it to detect numerous planets around other stars.[6] Recent research supported by NSF has solidified the case for the existence of a massive

[1] http://www.nasa.gov
[2] http://spacescience.nasa.gov
[3] http://www.nsf.gov
[4] http://www.nsf.gov/mps/ast
[5] http://exoplanets.org/teamframe.html
[6] http://exoplanets.org/

black hole at the center of our Galaxy, and provided high-resolution images of the oldest light emitted by the universe.

- NASA's OSS would also continue its successful Mars Exploration Program[7] with an increased request for FY 2005 of $691 million (see Table II-12). The two Mars Exploration Rovers[8] have landed on Mars and are producing images daily. The Mars Reconnaissance Orbiter[9] is proposed to receive $104 million in FY 2005 for development. Its role will be to understand the history of water on Mars. A new mission known as Phoenix[10] would receive $103 million. This University of Arizona led mission should land on Mars in 2008. It takes advantage of an existing lander and will search for evidence of a habitable zone that may exist in the ice-soil boundary on Mars, in addition to further investigations of the geologic history of water on the red planet.

- Astronomy is unique in the science community in the production of prioritized lists of projects requiring federal support. These so-called "Decadal Surveys" represent community consensus on the relative importance of scientific research projects. The surveys are carried out under the auspices of the National Academy of Sciences/National Research Council and sponsored by the funding agencies. The most recent astronomy and astrophysics survey is entitled *Astronomy and Astrophysics in the New Millennium.*[11] Two new reports were released in 2002, one that prioritizes the needs of the Planetary Science community (*A New Science Strategy for Solar System Exploration*[12]) and the second that covers the Solar and Space Physics community (*Solar and Space Physics: A Community Assessment and Strategy for the Future*).[13] The American Astronomical Society (AAS) has endorsed all three reports.

INTRODUCTION

NASA provides roughly 75 percent of the federal funding for astronomical research in the U.S. [14] When the OSS budget is changed,

[7] http://mars.jpl.nasa.gov
[8] http://mars.jpl.nasa.gov/missions/future/2003.html
[9] http://marsprogram.jpl.nasa.gov/mro/
[10] http://marsprogram.jpl.nasa.gov/missions/future/phoenix.html
[11] http://books.nap.edu/catalog/9839.html
[12] http://www.nationalacademies.org/ssb/ssefrontpage.html
[13] http://www4.nationalacademies.org/cpsma/SSBDisc.nsf
[14] http://www.nap.edu/books/0309071399/html/

many American astronomers can be affected, not to mention the workers in the aerospace industry who build the spacecraft that make these missions possible. NASA continues to provide observing opportunities for astronomers beyond the hindering absorption of the atmosphere. However, approximately two-thirds of federal support for ground-based astronomy, including nearly all support for radio astronomy, is provided by NSF.[15] NSF funds the construction and operation of the U.S. National Observatories.[16] These observatories play a critical role for researchers from smaller institutions for which large observing facilities are too expensive to construct and operate. They also provide access for American astronomers to the sky in the Southern hemisphere, where many important astronomical objects are located and cannot be observed from Northern hemisphere locations (*e.g.* the Magellanic Clouds, our nearest galactic neighbors).

Lately, the Department of Energy (DOE) has undertaken new astronomical research projects and the Smithsonian Institution and the Department of Defense also fund astronomical research, though on a smaller scale than both NASA and NSF.

A traditional, but arbitrary, split in funding exists between NASA and NSF with NASA funding *mostly* space-based observing and NSF funding *mostly* ground-based. This line is often blurred, since both agencies support balloon-based observing and other cross-cutting research. NASA does support ground-based observing when these activities have a direct supporting role for their space missions. A recent example is the Keck Interferometer,[17] and both agencies are pursuing collaborative efforts such as the National Virtual Observatory[18] program, which will interconnect databases, telescopic observations, space mission archives and research tools for astronomy and astrophysics. These collaborations reflect the way astronomers pursue their research, using any means necessary to study celestial objects. The Astronomy and Astrophysics Advisory Committee[19] meets regularly to discuss and advise on the best ways for agencies to collaborate on astronomy.

[15] http://www.nsf.gov/bfa/bud/fy2004/pdf/fy2004_11.pdf
[16] http://www.nsf.gov/mps/divisions/ast/about/c_facilities.htm
[17] http://huey.jpl.nasa.gov/keck/index.html
[18] http://www.srl.caltech.edu/nvo/
[19] http://www.aas.org/naaac/

ASTRONOMY IN THE NASA BUDGET

The overall NASA budget would increase significantly, from $15.4 billion to $16.2 billion in FY 2005, an increase of 5.6 percent (see Table II-12). Most areas of NASA would see growth, the exceptions being Education Programs, Aeronautics, and Earth Science, which all decline. The renamed Exploration, Science and Aeronautics portion of the agency's budget, which funds the bulk of the scientific research within the agency, would shrink slightly from $7.83 billion to $7.76 billion in FY 2005. Most of this $70 million decline is due to an 11 percent reduction in the Aeronautics portion of the budget.

NASA Administrator Sean O'Keefe announced in January, 2004 that future servicing missions to the Hubble Space Telescope[20] would not take place due to an integrated safety assessment. Senator Barbara Mikulski (D-MD), whose state hosts the Space Telescope Science Institute, has called for an independent review of the decision. As of this writing, a National Academies committee is being formed to provide advice to Congress and NASA on this issue. Hubble's batteries are a pressing issue. They should last until at least 2007, but if they fail, the telescope cannot be brought back to life. The fine guidance sensors, high-tech gyroscopes, are necessary for the highest resolution observations but are not required to maintain the observatory safely in orbit. Some talk of a robotic servicing mission has begun to get some airplay. The HST is arguably the most productive telescope of all time and plays an important role in US astronomy.

The Office of Space Science (OSS) would experience a small budgetary growth of $167 million or 4.2 percent from a level of just over $3.9 billion to a FY 2005 total of just over $4.1 billion. Much of this increase is due to increases in the Mars Exploration and Lunar Exploration lines, although the Astronomical Search for Origins also sees significant growth from $899 million to $1.1 billion. The Structure and Evolution of the Universe[21] (SEU) and Sun-Earth Connections lines would both receive cuts. SEU, which hoped to begin an ambitious new Beyond Einstein Initiative, would drop from $406 million to $378 million in FY 2005. Much of this program is now pushed back beyond a five-year horizon and some of the key large missions will be significantly reduced in the near-term. The budget also includes significant cuts to the

[20] http://www.stsci.edu/
[21] http://universe.gsfc.nasa.gov/

successful Explorer budget line, which funds university teams to design, develop and launch unique missions addressing the research questions posed by OSS. A transfer of a nuclear power propulsion effort out of the Solar System Exploration line explains most of this theme's reduction.

The goals of the Space Science Enterprise can be classified into five broad themes[22] (plus a new theme, Lunar Exploration):

Solar System Exploration (SSE), $1,187 million: The objective of this theme is to gain a deeper understanding of the formation and evolution of our Solar System and investigate whether life arose beyond Earth.

Mars Exploration (ME), $691 million: This theme seeks to probe into the past and present conditions on Mars, look for extinct/extant life forms and potentially pave the way for human exploration.

Astronomical Search for Origins (ASO), $1,067 million: This theme seeks to answer questions regarding the formation of stars and planets, the origin and properties of life and whether life exists beyond Earth.

Structure and Evolution of the Universe (SEU), $378 million: The objective of this theme is to gain a better understanding of the formation and evolution of the universe and deepen our knowledge regarding fundamental laws of space, time and energy.

Sun-Earth Connections (SEC), $746 million: This theme explores the properties of the Sun and the effects of solar activity on Earth.

Lunar Exploration (LE), $70 million: This new theme seeks to explore the moon and demonstrate technologies for research that can be used for more advanced explorations of our solar system, especially Mars.

The OSS has undertaken a series of programs/missions under these broad themes. Although too numerous to mention here, a few of the missions/programs stand out as particularly exciting (see Table 1):

[22] http://www.nasa.gov/pdf/55388main_05%20Space%20Science.pdf

Table 1 – Major Programs/Missions Undertaken by the OSS

Program/Mission[23]	FY 2005 Req. [millions of $] (theme)	Objective
MESSENGER, DAWN and Deep Impact missions	109 (SSE)	To explore Mercury, probe below the surface of a comet and examine the properties of two asteroids
New Horizons	116 (SSE)	The first mission will perform reconnaissance of the planet Pluto and its moon Charon
Astrobiology research	75 (SSE)	To improve the ability to find and identify life on other planets
2005 Mars Reconnaissance Orbiter	104 (ME)	Map surface features as small as a basketball to understand the history of water on Mars and identify the best sites for future landings
2007 Phoenix	103 (ME)	Mars Scout mission to analyze surface and subsurface water and ice
2009 Mars Space Laboratory	175 (ME)	A rover that will traverse tens of kilometers for over a year, digging and drilling for unique samples to study in its onboard laboratory
Lunar Exploration	70 (LE)	A new theme to support activities that will sustain human and robotic exploration of Mars and other bodies
Hubble Space Telescope	130 (ASO)	Maintain current operational capability, as well as funding for a robotic deorbiting mission
James Webb Space Telescope	318 (ASO)	Develop the next-generation space telescope to observe the first stars and galaxies and help determine the shape and fate of the Universe
Space Interferometry Mission	155 (ASO)	Detect planets around other stars using high-resolution and starlight nulling imagery
Gamma-ray Large Area Space Telescope	103 (SEU)	Study high-energy objects such as black holes
STEREO/Solar Dynamics Observatory	232 (SEC)	Study the Sun's magnetic field and the dynamic processes that influence space weather
Future Missions	242 (SEC)	Planning/construction future missions

[23] http://spacescience.nasa.gov/missions/index.htm [all missions index]

ASTRONOMY IN THE NSF BUDGET

NSF funds astronomy through its Division of Astronomical Sciences.[24] This funding is split into two basic units, Astronomy Research and Instrumentation (which funds individual researchers, infrastructure and instrument development projects and some research facilities such as the Science and Technology Center for Adaptive Optics[25]) and Facilities, which supports the four national R&D centers (National Radio Astronomy Observatory,[26] National Optical Astronomy Observatories,[27] National Solar Observatory,[28] and National Astronomy and Ionosphere Center[29]), as well as the International Gemini Observatory[30](see Table 2).

Table 2 – FY 2004 & 2005 Budget Requests for Astronomy Facilities

Astronomy Facility	FY 2004 Estimate [$ millions]	FY 2005 Request [$ millions]
Gemini Observatories[31]	14.12	14.93[32]
National Astronomy and Ionosphere Center[33]	10.54	10.60
National Optical Astronomy Observatories[34] and National Solar Observatory[35]	41.35	39.00[36]
National Radio Astronomy Observatory[37]	54.98[38]	47.41

[24] http://www.nsf.gov/mps/ast
[25] http://cfao.ucolick.org/
[26] http://www.nrao.edu/
[27] http://www.noao.edu/
[28] http://www.nso.edu/
[29] http://www.naic.edu/
[30] http://www.gemini.edu/
[31] http://www.gemini.edu/
[32] Included is $1.0 million for partial return of the U.S. share of Chilean capital.
[33] http://www.naic.edu/
[34] http://www.noao.edu/
[35] http://www.nso.edu/
[36] Includes $35.0 million for NOAO and NSO telescopes, plus $4.0 million for TSIP (Telescope System Instrumentation Program), a program which funds instrument development and construction at private observatories in return for observing time on those facilities.
[37] http://www.nrao.edu/
[38] Amount included a one-time payment for major repairs to the Green Bank telescope tract structure and accelerated work on the EVLA.

The Astronomy Division budget would increase in the President's FY 2005 budget by 4 percent, compared to a 13.5 percent increase in 2004 (see Table II-7). The Astronomy Research and Instrumentation portion is proposed to increase from $77.2 million to $92.4 million. Astronomy Facilities would see an increase of $6.1 million over FY 2004 to a FY 2005 request for $111.9 million. Priorities in this year's budget focus on studies in cosmology and the origin and evolution of the universe and the formation of starts and planets. A new area of research centers on the Large Synoptic Survey Telescope (LSST), an instrument concept that will explore the nature of dark energy and the distribution of dark matter.

Astronomy is also supported within the NSF budget through the Office of Polar Programs[39] (OPP), Major Research Equipment and Facilities Construction (MREFC) and Multidisciplinary Activities budget lines. The FY 2005 request for the IceCube Neutrino Observatory, an extension of the successful AMANDA project, is $33.4 million. Atacama Large Millimeter Array[40] (ALMA) telescope construction would continue in FY 2005 at $49.67 million, down $1.1 million. Construction of VERITAS (Very Energetic Radiation Imaging Telescope Array System), an array of four twelve-meter aperture telescopes for the study of high energy gamma rays, and the operation of CDMS II, an underground experiment to search for dark matter principles, will continue in partnership with NSF's Physics Division and DOE.

ASTRONOMY ELSEWHERE IN THE BUDGET

Both the Navy and Air Force fund small amounts of fundamental astronomical research for national security purposes; this support is important as it represents multidisciplinary involvement in astrophysical research. DOE's Office of Science also funds astrophysical research. One example is the Supernova Acceleration Probe[41] (SNAP), which would receive $7.6 million in FY 2005. The Smithsonian Institution supports a wide array of astronomical research through its Center for Astrophysics[42], including telescopes in Hawaii and Arizona. The Submillimeter Array[43], an innovative high-frequency radio telescope, is nearing operational completion on the summit of Mauna Kea in Hawaii.

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[39] http://www.nsf.gov/od/opp
[40] http://www.alma.nrao.edu/
[41] http://snap.lbl.gov/
[42] http://cfa-www.harvard.edu/
[43] http://sma-www.harvard.edu/