Order Code RL32988

The National Aeronautics and Space Administration's FY2006 Budget Request: Description, Analysis, and Issues for Congress

Updated August 1, 2005

Marcia S. Smith and Daniel Morgan
Resources, Science, and Industry Division

The National Aeronautics and Space Administration's FY2006 Budget Request: Description, Analysis, and Issues for Congress

Summary

For FY2006, the National Aeronautics and Space Administration (NASA) is requesting $16.456 billion. That amount is a 2.4% increase over the $16.070 billion (adjusted for the rescission) appropriated in the FY2005 Consolidated Appropriations Act (P.L. 108-447). NASA also received a supplemental of $126 million for hurricane relief, for a total FY2005 appropriated level of $16.196 billion. The FY2006 request is 1.6% above that total amount. By comparison, last year the White House projected that NASA's budget would increase by 4.7%. NASA submitted a FY2006 budget amendment on July 15; total funding for the agency did not change.

Congress is debating both appropriations and authorization bills for NASA. NASA's appropriations are in the FY2006 Science, State, Justice, Commerce (SSJC) appropriations bill (H.R. 2862). The House-passed version approves $15 million above the request. The Senate version, as reported from committee (S.Rept. 109-88), cuts the request by $60 million. The House-passed NASA authorization bill (H.R. 3070), following adoption of a manager's amendment, includes $510 million more than the request. The Senate version, as reported from the Senate Commerce Committee (S. 1281, S.Rept. 109-108), recommends $100 million above the request.

Debate over NASA's FY2006 request centers on plans to implement the Vision for Space Exploration, announced by President Bush in January 2004. The Vision calls for NASA to return humans to the Moon by 2020, and someday send them to Mars. President Bush did not propose adding significant funding to NASA's five-year budget plan to implement the Vision. Instead, the agency must redirect funds from its other activities. NASA's resources are being strained by that decision, increased funding demands for returning the space shuttle to flight status, cost growth in existing programs, and the need to fund congressionally-directed items.

NASA Administrator Dr. Michael Griffin testified to Congress in May 2005 that NASA cannot afford all the programs currently on its plate, and priorities must be set. He also is changing the emphasis on some of the Vision-related activities. For example, he is accelerating development of a Crew Exploration Vehicle (CEV) to reduce an expected multi-year gap between when the space shuttle is to be terminated (2010) and the availability of the CEV. During that gap, the United States would not have its own ability to launch astronauts, and thus would be dependent on Russia for crew transportation to the International Space Station (ISS). To pay for accelerating the CEV, Dr. Griffin plans to reduce funding for other Vision-related activities such as developing nuclear power and propulsion systems (Project Prometheus) or performing research on ISS.

NASA's FY2006 budget request also assumes a reduction of about 2,500 NASA civil servants by the beginning of FY2007. As it considers the FY2006 request, Congress is debating whether to adopt the Vision, and if it does, the resulting impact on NASA's other activities and the agency itself. This report will be updated. An abbreviated version is available as CRS Report RS22063.

Contents

List of Figures

List of Tables

The National Aeronautics and Space Administration's FY2006 Budget Request: Description, Analysis, and Issues for Congress

Preface

This report discusses the major issues being debated in the context of NASA's FY2006 request for $16.456 billion, a 2.4% increase over the $16.070 billion appropriated in the FY2005 Consolidated Appropriations Act (adjusted for the rescission). NASA also received $126 million in a FY2005 supplemental for hurricane relief, giving it a total of $16.196 billion for FY2005. The FY2006 request is a 1.6% increase above that total. By comparison, last year's budget submission projected that the agency would receive a 4.7% increase for FY2006. NASA submitted a FY2006 budget amendment on July 15, 2005; total funding requested did not change, only how it is allocated within the agency.

NASA substantially changed its budget structure in the FY2006 budget request, as it has done repeatedly over the past several years. The agency also shifted to "full cost accounting" in FY2004. These changes make comparisons across fiscal years at the program level virtually impossible. Comparing the FY2005 appropriation and the FY2006 request alone is difficult. In its FY2006 request, NASA provided estimated FY2005 funding figures, taken from its Initial Operating Plan (December 23, 2004), using the same structure as the FY2006 budget to enable comparisons between those years. However, NASA's FY2005 spending plans have changed significantly since then, as explained in a May 10, 2005 update to the operating plan.[1] The operating plan update was presented in the budget structure NASA used for FY2005, not FY2006, with no"crosswalk" between the old and new structures. Thus, those numbers cannot be incorporated into the tables in this report. Major changes are discussed in the text, however.

The most prominent issues in the FY2006 budget are carry-overs from the FY2005 debate: whether to approve President Bush's "Vision for Space Exploration" to return astronauts to the Moon by 2020 and then go on to Mars and "worlds beyond"; returning the space shuttle to flight status following the February 2003 space shuttle *Columbia* tragedy; the future of U.S. use of the International Space Station; and whether to use the shuttle to service the Hubble Space Telescope.

---

[1] NASA's operating plans are discussed below under **Overview of NASA's FY2006 Budget Request**.

Another major issue this year is the future of NASA's aeronautics research programs, which are slated for significant reductions.

Several other CRS reports are available on NASA-related topics, and are referenced herein. For convenience, a list is provided in Appendix A. An abbreviated version of this report is available as CRS Report RS22063, *The National Aeronautics and Space Administration: Overview, FY2006 Budget in Brief, and Key Issues for Congress.*

FY2005 estimated, and FY2006 requested, budget figures are from NASA's budget justification documents [http://www.nasa.gov/about/budget/index.html], and, where indicated, from a budget amendment submitted by the White House [http://www.whitehouse.gov/omb/budget/amendments/amendment_7_15_05.pdf] on July 15, 2005. Program descriptions are condensed from material provided by NASA in that or previous budget justifications, and previous CRS reports in this series.

Introduction to NASA

NASA was created by the 1958 National Aeronautics and Space Act (P.L. 85-568), and opened its doors on October 1, 1958.[2] NASA's charter is to conduct civilian space and aeronautics activities. Military space and aeronautics activities are conducted by the Department of Defense (DOD) and the intelligence community. The organizations cooperate in some areas of technology development and occasionally have joint programs.

NASA began operations almost exactly one year after the Soviet Union ushered in the Space Age with the launch of the world's first satellite, Sputnik, on October 4, 1957. In the 47 years that have elapsed, NASA has conducted far reaching programs in human and robotic spaceflight, technology development, and scientific research. The agency is managed from NASA Headquarters in Washington, D.C. It has nine major field centers around the country (see **Figure 1**):

- **Ames Research Center**, Moffett Field, CA, which also manages Moffett Federal Airfield, Mountain View, CA.;
- **Dryden Flight Research Center**, Edwards, CA;
- **Glenn Research Center**, Cleveland, OH;

---

[2] The National Advisory Committee for Aeronautics (NACA), chartered in 1915, served as the nucleus for NASA. The day that NASA began operations, five NACA research facilities were transferred to NASA, and all continue to operate today: Ames Research Center, Dryden Flight Research Center, Glenn Research Center (formerly Lewis Research Center), Langley Research Center, and Wallops Flight Facility. Two Army organizations also were transferred to NASA within a year of the agency's creation: the Development Operations Division of the Army Ballistic Missile Agency — the "von Braun team" — which developed the Jupiter C launch vehicle that placed the first U.S. satellite into orbit on January 31, 1958 (prior to NASA's creation), now called Marshall Space Flight Center; and the Jet Propulsion Laboratory, which developed that satellite (Explorer 1).

- **Goddard Space Flight Center**, Greenbelt, MD, which also manages the Goddard Institute of Space Studies (New York, NY), the Independent Validation and Verification Facility (Fairmont, WV), and the Wallops Flight Facility (Wallops, VA);
- **Johnson Space Center**, near Houston, TX, which also manages NASA activities at the White Sands Test Facility, White Sands, NM;
- **Kennedy Space Center**, near Cape Canaveral, FL;
- **Langley Research Center**, Hampton, VA;
- **Marshall Space Flight Center**, Huntsville, AL; and
- **Stennis Space Center**, in Mississippi, near Slidell, LA.

The **Jet Propulsion Laboratory**, Pasadena, CA, often counted as a 10th NASA center, is a federally funded research and development center (FFRDC) operated for NASA by the California Institute of Technology.[3] **Figure 1** shows the locations of these facilities. See [http://www.nasa.gov/about/highlights/OrganizationIndex.html] for links to all of NASA's facilities.

According to information supplied to CRS by NASA in March 2005, and NASA's workforce website [http://nasapeople.nasa.gov/workforce/default.htm], NASA employs approximately 19,000 full time equivalent (FTE) civil servants.[4] The website also estimates that NASA has 40,000 on-site and near-site support contractors and grantees. Significant workforce cutbacks are planned by the beginning of FY2007 as NASA "transforms" itself to implement President Bush's Vision for Space Exploration. That issue is discussed below.

NASA is headed by an Administrator. Dr. Michael Griffin was sworn in as NASA's 11th Administrator on April 14, 2005. Dr. Griffin has extensive experience in military and civilian space programs, and has served in a number of private sector and government capacities (including previous service at NASA). Immediately prior to his appointment as Administrator, he was Space Department Head at Johns Hopkins University's Applied Physics Laboratory. His predecessor as Administrator was Mr. Sean O'Keefe.

NASA Headquarters is currently organized into four Mission Directorates: Aeronautics Research, Exploration Systems, Science, and Space Operations. NASA Headquarters' current organization chart is provided in **Figure 2**.

---

[3] Despite its name, JPL's primary role for NASA is developing earth-orbiting and planetary exploration spacecraft, and managing the Deep Space Network, which tracks and communicates with planetary spacecraft.

[4] A NASA official told the House Science Committee on February 17, 2005 that NASA had 18,000 employees, an apparent reference to full-time permanent (FTP) employees, not the more commonly used "full time equivalents" (FTEs), which are budget-related estimates of the number of work years required to achieve agency missions and objectives. According to data provided to CRS by NASA in March 2005, the FY2005 NASA budget funds 19,227 FTEs, and the FY2006 budget would fund 18,798 FTEs; the actual number of employees was 18,932, of which 17,475 were FTPs. Those data also show that NASA plans to reduce its FTE level to 16,738 by FY2007, a reduction of 2,489 from its current level. Other NASA information indicates that as many as 2,673 positions may be eliminated.

Figure 1. NASA Facilities

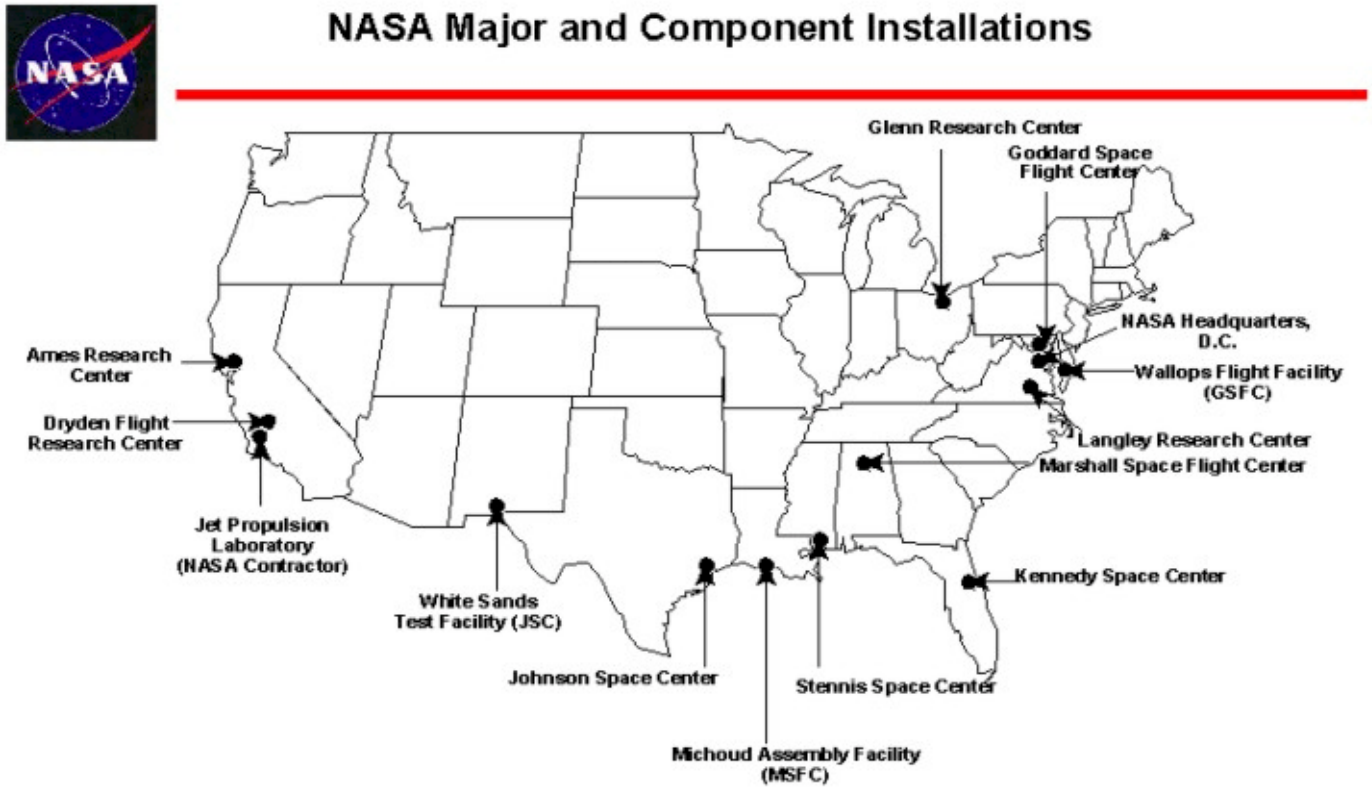
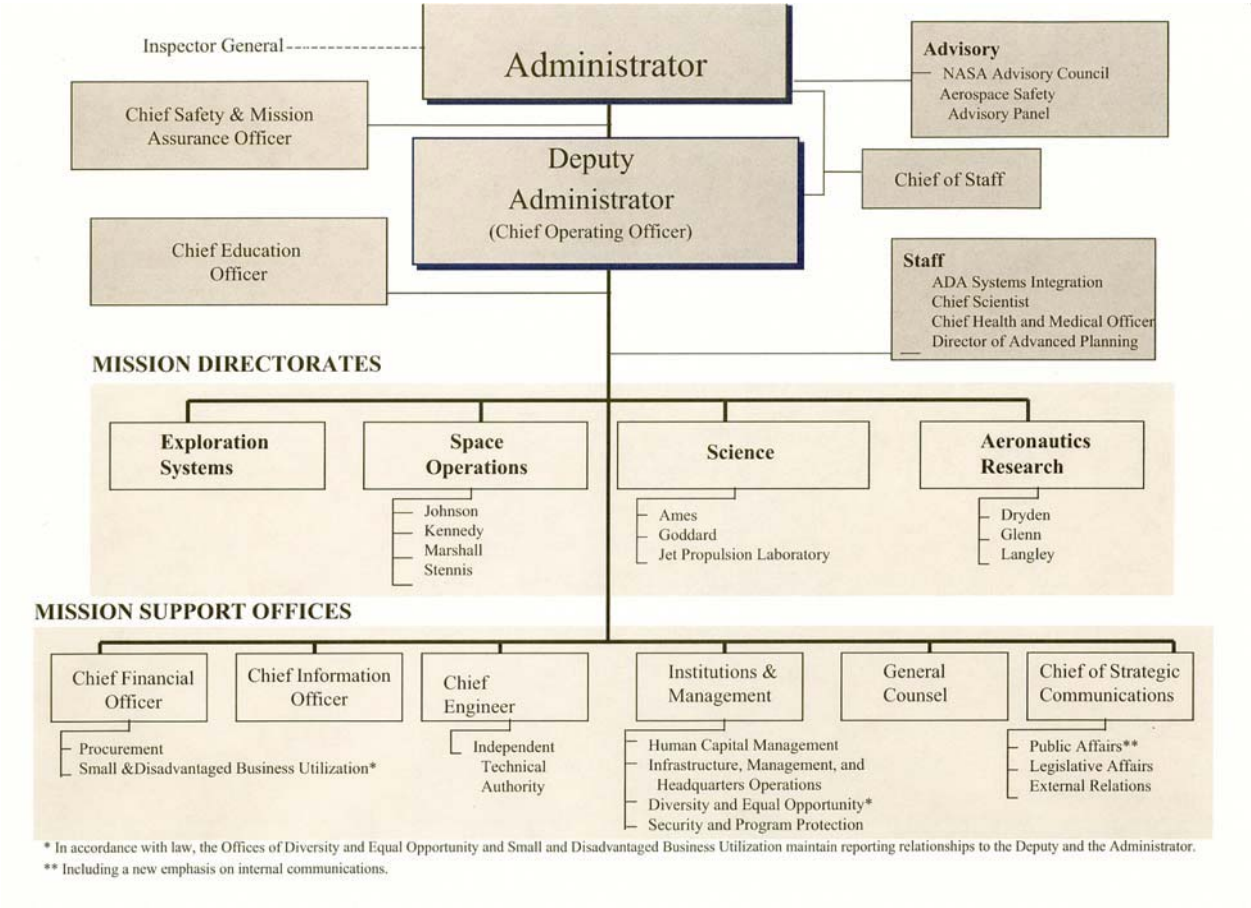


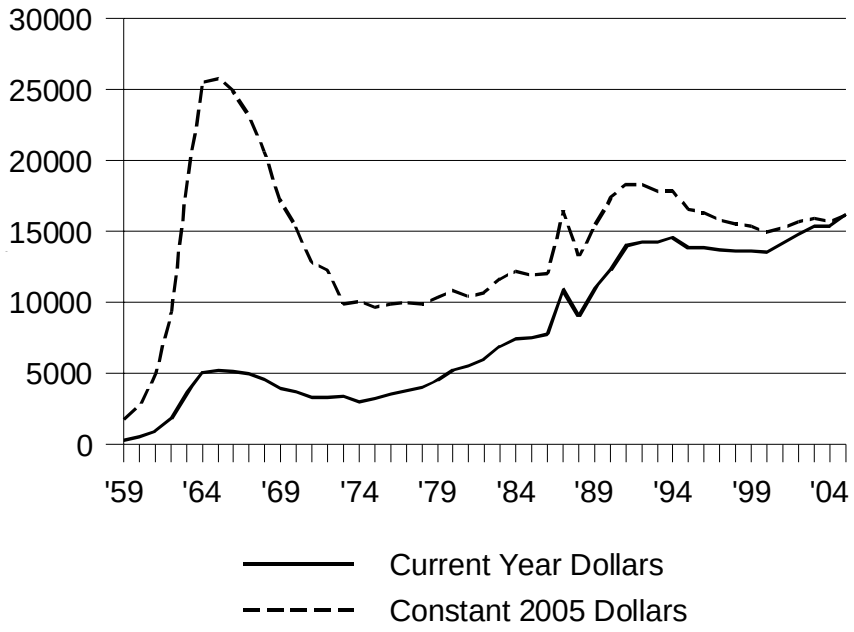
Figure 2. NASA's Organization Chart



NASA's Historical Budget

Since its creation in 1958, NASA has experienced periods of budget growth and decline, some of which were dramatic. **Figure 3** displays the agency's budget history, both in current year dollars (i.e., unadjusted for inflation) and in constant 2005 dollars (i.e., adjusted for inflation). In the early 1960s, as the nation strived to put an American on the Moon by 1969, NASA's budget increased rapidly, peaking at $5.25 billion (current dollars) in FY1965. Then, as other national priorities gained precedence, NASA's budget declined sharply to about $3 billion (current dollars) by FY1974. Subsequently, it increased steadily for almost two decades (the one-year spike in 1987 was to build a replacement space shuttle orbiter), but declined in the mid-1990s as efforts to restrain federal funding took hold. It rose gradually (in current dollars) thereafter. President Bush's Vision for Space Exploration called for NASA's budget to increase by about 5% in FY2005-2007. That occurred for FY2005, but the FY2006 budget request is less than what had been projected last year (see below).

Figure 3. NASA Budget Authority FY1959-2004 — Current and Constant Dollars (in $millions)



Does not include Transition Quarter.

Source: Current dollars for 1959-2003 are from the Aeronautics and Space Report of the President: FY2003; for 2004-2005, from the Historical Tables of the Budget of the U.S. Government, FY2006. Constant dollars (adjusted for inflation to reflect 2005 dollars) were calculated by CRS using the GDP (chained) price index. The spike in NASA funding in 1987 was to cover the costs of building a replacement orbiter after the 1986 Space Shuttle *Challenger* tragedy.

Table 1. NASA Budget Authority, Past Ten Years (1996-2005)
(in millions of dollars)

Fiscal Year	Current Dollars (unadjusted for inflation)	Constant 2005 Dollars (adjusted for inflation)
1996	13,884	16,332
1997	13,709	15,840
1998	13,648	15,581
1999	13,653	15,384
2000	13,601	15,022
2001	14,230	15,355
2002	14,868	15,751
2003	15,364	15,998
2004	15,379	15,692
2005	16,197	16,197

Source: Current dollars for 1959-2003 are from the Aeronautics and Space Report of the President: FY2003; for 2004-2005, from the Historical Tables of the Budget of the U.S. Government, FY2006. Constant dollars (adjusted for inflation to reflect 2005 dollars) were calculated by CRS using the GDP (chained) price index.

Congressional Committee Reorganizations

Historically, NASA has been part of the appropriations bill covering the Department of Housing and Urban Development (HUD), Department of Veterans Affairs (VA), and Independent Agencies, including the National Science Foundation and the Environmental Protection Agency. The House and Senate appropriations subcommittees with oversight over that bill were dubbed the "VA-HUD-IA" subcommittees. In the 109th Congress, the House decided to reorganize its Appropriations Committee, reducing the number of subcommittees from 13 to 10. The VA-HUD-IA subcommittee was one of those abolished. NASA now is part of the newly established Science, State, Justice, Commerce (SSJC) subcommittee. Press accounts[5] trace the origin of the reorganization to House Majority Leader Tom DeLay's dissatisfaction with deep cuts for NASA recommended by the VA-HUD-IA subcommittee in the FY2005 deliberations (see CRS Report RL32676), and a desire to eliminate the funding competition between NASA and other popular programs such as housing and veterans medical care.

The Senate also eliminated its VA-HUD-IA subcommittee, but retained a total of 12 subcommittees (down from 13). NASA was moved into the newly established

[5] For example, see U.S. House Republican Pushes for Spending Change, Reuters, February 9, 2005 (via Factiva); and Hulse, Carl, There's No Talk of Dollars in This Battle Over the Budget, New York Times, February 16, 2005 (via Factiva)

Commerce, Justice, and Science (CJS) subcommittee. The Senate CJS subcommittee's jurisdiction is different from its House counterpart in that the House subcommittee includes the State Department.

NASA's Senate authorizing committee, the Senate Commerce, Science, and Transportation Committee, also reorganized its subcommittee structure. Previously, NASA was part of the Science, Technology and Space Subcommittee. In this case, the committee added several new subcommittees, and technology issues were moved to a different one. The subcommittee that oversees NASA is now named the Science and Space Subcommittee. The House Science Committee, which authorizes NASA activities in the House, maintained the same structure as in the 108th Congress, with NASA issues under the purview of the Space and Aeronautics Subcommittee.

Overview of NASA's FY2006 Budget Request

NASA is requesting $16.456 billion for FY2006, a 2.4% increase over the $16.070 billion (adjusted for the rescission) appropriated in the FY2005 Consolidated Appropriations Act (P.L. 108-447). NASA also received $126 million in a FY2005 supplemental for hurricane relief (P.L. 108-324), giving it a total of $16.196 billion for FY2005. The FY2006 request is a 1.6% increase above that total. Last year, NASA was projected to receive a 4.7% increase for FY2006. NASA has substantially changed its budget structure again, as it has each year for the past several years, making comparisons across fiscal years difficult. Footnotes to **Table 2** explain budget structure changes from FY2005.

NASA submitted a FY2006 budget amendment on July 15, 2005, available at [http://www.whitehouse.gov/omb/budget/amendments/amendment_7_15_05.pdf]. It reflects, in part, the shifting of two programs into the Exploration Systems Mission Directorate (ESMD): ISS Crew/Cargo services ($168 million) from the International Space Station theme in the Space Operations Mission Directorate, and the Lunar Robotic Exploration Program ($135 million) from the Solar System Exploration theme in the Science Mission Directorate. These changes are consistent with the statement in NASA's May 10, 2005 operating plan update that these moves had been made for FY2005. Thus, the FY2006 funding request for the ESMD increases by $303 million in the budget amendment. The budget amendment makes a number of other changes, which are discussed elsewhere in this report as appropriate.

Some of the fields in Table 2 are necessarily blank because of how the various congressional committees have acted on the bills. Although increases and decreases for specific programs are noted in the text of the House and Senate committee reports accompanying the appropriations bill (H.R. 2862), overall funding levels are identified only at the account level. The Senate version of the authorization bill (S. 1281) also identifies funding only at the account level. The House-passed authorization bill creates a different account structure than that used in NASA's request, and it cannot be adapted for use in Table 2. Therefore, Table 2 shows only the total for the agency recommended in H.R. 3070. See **Table 3** for the structure and funding levels recommended in H.R. 3070.

Table 2. NASA's FY2006 Budget Request

(Budget Authority, in millions of dollars)

Category	FY2005	FY2006				
	Estimate (Initial Op. Plan)	Request (Amended)	Appropriations		Authorization	
			House passed	Senate cmte	House passed	Senate cmte
Science, Aeronautics, and Exploration	****7,619**	****9,829**	**9,726**	**9,761**		**9,661**
Science [A]	5,527	5,342				
Aeronautics	906	852				
Biol. and Phys. Research	1,004	— [B]				
Exploration Systems	25	3,469				
Education	217	167				
Exploration Capabilities	****8,358**	****6,595**	**6,713**	**6,603**		**6,863**
Space Operations	6,704	6,595				
- Space Shuttle	*4,543*	*4,531*				
- International Space Station	*1,676*	*1,689*				
- Space and Flight Support	*485*	*376*				
Exploration Systems	1,654	— [C]				
Inspector General	**31**	**32**	**32**	**32**		**32**
Total Regular Appropriations	**16,070**	**16,456**	**16,471**	**16,396**	**16,966**	**16,556**
FY2005 Hurricane Suppl.	**126**					
Grand Total	**16,196**	**16,456**	**16,471**	**16,396**	**16,966**	**16,556**

Source: FY2005 Estimate and FY2006 Request from the Office of Management and Budget [http://www.whitehouse.gov/omb/budget/fy2006/nasa.html], except for space shuttle, space station, and space and flight support, which are from NASA's FY2006 budget justification. Grand Total was added by CRS. The FY2006 request figures are adjusted for the July 15, 2005 budget amendment. Appropriations and authorization figures are from NASA FY2006 funding bills (H.R. 2862, H.R. 3070, and S. 1281) and associated committee reports. The budget amendment was submitted after the committees had acted on the original request. Totals may not add due to rounding.

* Figures in this column are from the December 23, 2004 version of NASA's operating plan, as provided in NASA's FY2006 budget justification documents. An updated version of the operating plan, dated May 10, 2005, is available on NASA's budget website [http://www1.nasa.gov/pdf/115071main_FY05_op_plan_may.pdf]. The May update is presented in the budget structure used for the FY2005 budget, however, and cannot be used to update this table (which is in the FY2006 budget structure).

** The FY2005 totals for the SA&E and Exploration Capabilities accounts are different from those in the table included in NASA's FY2006 budget justification documents because OMB shows the shift of "Exploration Systems" from one account to the other. The NASA table uses the FY2006 budget structure without showing a "trace" between last year's budget presentation and this year's. Since the OMB data show that trace, and include FY2004, they are used in this report.

[A] In the FY2006 request, " Science" incorporates the former Space Science and Earth Science line items.

[B] In the FY2006 request, Biological and Physical Research became part of Exploration Systems.

[C] In the FY2006 request, funding for Exploration Systems was moved into the SA&E account.

Congress gave NASA significant latitude in how it could spend its FY2005 funding. The conference report refers to it as "unrestrained transfer authority" between NASA's two major budget accounts. NASA must notify Congress of how it plans to spend the money, and is doing so through the traditional process of submitting periodic "operating plans." An Initial Operating Plan was sent to Congress on December 23, 2004,[6] but it stated that further changes would be forthcoming. The most recent revision was submitted to Congress on May 10, 2005.[7]

Despite the fact that NASA received approximately the same amount that it requested in FY2005, the agency is under significant funding constraints. As noted, $126 million of the total is a supplemental to help NASA recover from the hurricanes that damaged NASA facilities at Kennedy Space Center, FL in 2004. The NASA budget was subject to an across-the-board rescission, reducing the appropriated level from $16.200 billion to $16.070 billion. More than $1 billion in other funding must be spent on activities that were not included in the FY2005 request: increased costs for returning the shuttle to flight status ($762 million); congressionally directed items (approximately $400 million, including $291 million to service the Hubble Space Telescope); and cost increases in other NASA programs. NASA Administrator Griffin testified to the Senate Appropriations CJS subcommittee on May 12, 2005, about one month after he took office. His statement covered both the FY2006 request, and the May 10 update to the FY2005 operating plan. He emphasized that NASA does not have sufficient money to fund all the programs it has on its plate for FY2005, and priorities must be set. His priorities are discussed below.

As noted by the House and Senate Appropriations Committees, and the House Science Committee, in their reports on NASA's funding bills (see below), NASA's FY2006 budget justification documents contained significantly less detail than in previous years. The committees directed NASA to provide more detail in the future. However, because of that lack of detail in publicly available documents, it is not always possible in the lists below of committee actions to indicate the amount that was requested for a particular activity.

Appropriations Action on the FY2006 Request

House (H.R. 2862). The House SSJC appropriations subcommittee marked up its version of the FY2006 appropriations bill on May 24, 2005. It was reported from the full committee on June 10 (H.R. 2862, H.Rept. 109-118), and passed the House on June 16. The committee recommended, and the House approved, $16.471 billion for NASA, a net increase of $15 million above the request. In total, the House added $64.76 million for the Science, Aeronautics, and Exploration account, and cut $50 million from the Exploration Capabilities account as follows:

---

[6] The December 23, 2004 plan was publicly released by NASA in February 2005 and is used in NASA's FY2006 budget justification, available at [http://www1.nasa.gov/about/budget/].

[7] The May 10, 2005, update to the operating plan is available on NASA's website at [http://www1.nasa.gov/pdf/115071main_FY05_op_plan_may.pdf].

Science, Aeronautics, and Exploration

- An increase of $30 million for the Glory earth sciences mission ($5 million was requested);
- An increase of $10 million for the Space Interferometry Mission;
- An increase of $54 million for aeronautics research, restoring it to its FY2005 level ($906 million);
- An increase of $2 million for education programs ($167 million was requested);
- An increase of $50 million for continuation of unspecified congressionally-directed programs that were terminated in the budget request;
- A decrease of $25 million from exploration systems research and technology ($919 million was requested);
- A decrease of $25 million from human systems research and technology ($807 million was requested);
- A decrease of $31 million from corporate administrative costs, of which $10 million is from the Office of Advanced Planning and Integration, which the committee said was being eliminated; and
- A direction that $10 million of the funds provided for non-programmatic construction of facilities be allocated for the Institute for Scientific Research, Inc. for construction of research facilities.

Exploration Capabilities

- A decrease of $10 million from the International Space Station ($1.86 billion was requested);
- A decrease of $10 million from ISS Crew/Cargo Services (included in the ISS request above);
- A decrease of $10 million from Rocket Propulsion Testing ($69 million was requested);
- A decrease of $10 million from Space Communications ($173 million was requested); and
- A decrease of $10 million from Launch Services ($124 million was requested), but none can be taken from the Small Payload Launch program.

Senate (H.R. 2862). The Senate CJS appropriations subcommittee marked up its version of H.R. 2862 on June 21, and the bill was reported from the full committee on June 23 (S.Rept. 109-88). The bill recommended a net cut of $60 million, adding $100 million for the Science, Aeronautics, and Exploration account, and cutting $160 million from the Exploration Capabilities account. The report lists several specific increases, but only two specific decreases, which do not total the $60 million net reduction. The report makes a number of recommendations about funding levels, and in some cases directs NASA to spend funding in a certain manner. In many cases, these do not involve increases above a requested funding level, but instead are instructions on how to spend the funds. In other cases, it is not clear if it is an increase, or a specified allocation.

Science, Aeronautics and Exploration

- An increase of $250 million for a Hubble servicing mission (none was requested for a servicing mission, although $191 million is requested for the Hubble program);
- An increase of $30 million for the National Center for Advanced Manufacturing;
- An increase of $15 million for Earth Science Applications ($52 million was requested) was included in a recommendation of "$102,837,000 million within this account to supplement the areas of earth science and exploration";
- A direction that $50 million be allocated for unspecified congressionally-directed initiatives terminated in the budget request;
- A direction that $20 million of Exploration Systems funding be used for the evaluation of alternative small spacecraft technologies with the potential for dramatically lowering planetary exploration costs;
- A recommendation that $25 million be used to continue hypersonic engine technology research (none was requested);
- A direction that the Research Partnership Centers and the University Research Engineering and Technology Institutes be funded at the same level as in FY2005 (precise figures were not provided either in NASA's budget documentation or in the committee's report);
- A recommendation that within the funds for education, $12 million be for EPSCoR, $29.55 million for the Space Grant program, and $54.233 million for other education-related activities (EPSCoR and Space Grant are discussed later in this report, the total requested for education is $167 million);
- A recommendation that $10 million be allocated to research and development for integrated radiation shielding protection, regenerative environmental control and life support systems, advanced life support air revitalization, and integrated vehicle health management through the ECLSS Life Test program office;
- A recommendation that, within the funds provided, $20 million be allocated for the Propulsion Research Laboratory to perform nuclear thermal propulsion systems development, and research on other advanced nuclear power propulsion; and
- A decrease of $34 million (the entire request) for the Centennial Challenges program.

Exploration Capabilities

- A decrease of $160 million (the entire request) from ISS Crew/Cargo Services.

Authorization Action on the FY2006 Request

Congress also is debating an authorization bill for NASA. The House-passed version (H.R. 3070, H.Rept. 109-173) is a two-year bill providing funding for FY2006 and FY2007. The Senate version, as reported from the Senate Commerce, Science, and Transportation Committee (S. 1281, S.Rept. 109-108), is a five-year

bill, for FY2006-2010. The most recent NASA authorization act was enacted in 2000 and covered FY2000-2002 (P.L. 106-391). The pending authorization bills contain extensive policy provisions that are too numerous to include in this report. This report summarizes only the provisions that affect the major issues identified herein. The following paragraphs pertain to funding recommendations in the bills. Policy recommendations are addressed in later sections of this report as appropriate.

House (H.R. 3070). H.R. 3070, as passed by the House on July 22, 2005, authorizes funding for FY2006 and FY2007.

Committee Action. As reported from the House Science Committee (H.Rept 109-173), the total for FY2006 was the same as approved in the House version of the appropriations bill (see above) — $16.471 billion, a $15 million increase over the request. The level for FY2007 was the same as the projected request in NASA's budget documents — $16.962 billion. As discussed below, these figures changed significantly in the House-passed version of the bill.

During committee markup, an amendment in the nature of a substitute was adopted that reflected a compromise between H.R. 3070 as approved by the Space and Aeronautics Subcommittee on June 29, and H.R. 3250 (Gordon), a Democratic substitute that was introduced after subcommittee markup. Most Democratic members of the subcommittee abstained from voting on H.R. 3070 during subcommittee markup because they said they had insufficient time to review it. The amended version of H.R. 3070 that cleared the full committee is quite different from the earlier version of H.R. 3070, and from H.R. 3250.

The amended bill adopts the budget structure proposed in H.R. 3250, which is different from the one used in NASA's FY2006 budget request. Instead of three accounts (Science, Aeronautics, and Exploration; Exploration Capabilities; and Inspector General), the bill creates four accounts: Science, Aeronautics and Education; Exploration Systems; Space Operations; and Inspector General. Thus, funding for "exploration" would be in its own account, instead of with science, aeronautics and education. According to comments at the markup, the intent is to create budgetary "firewalls" that would require closer congressional scrutiny if funding is shifted from one set of activities (e.g., science, aeronautics and education) into another (e.g., exploration). The goal is to maintain balance among NASA's activities. The recommended budget structure is shown in **Table 3**.

The committee shifted some programs from one account to another. As explained in the report (H.Rept. 109-173), the new Science, Aeronautics and Education account would include all the programs in the current Science, Aeronautics and Education lines proposed in the request, except that the Robotic Lunar Exploration program would be transferred from Science to Exploration Systems. The Exploration Systems account would include all programs currently in the Exploration Systems line in the FY2006 request, as well as the Robotic Lunar Exploration Program, and two activities transferred from the Space Operations account — Space and Flight Support, and ISS Crew/Cargo Services. The new Space Operations account would include only the space shuttle and the International Space Station (minus the ISS Crew/Cargo Services activity).

H.R. 3070, as reported, further specified that, for FY2006, of the amount in the Science, Aeronautics and Education account, $962 million was for aeronautics, $150 million was for a Hubble servicing mission (see below), and $24 million was for the National Space Grant College and Fellowship program. For FY2007, the bill as reported from committee specified that, of the amounts in the Science, Aeronautics and Education account, $990 million was for aeronautics, and $24 million was for the National Space Grant College and Fellowship program.

Floor Action. The House adopted a manager's amendment during floor debate on H.R. 3070 that significantly increased the authorization level for both FY2006 and FY2007. The new amounts are shown in Table 3. In total, $510 was added for FY2006, and $765 million for FY2007. The amounts for Science, Aeronautics and Education are unchanged from the committee-reported bill. The total for Exploration Systems increases by $663 million in FY2006 and by $925 million in FY2007. The total for Space Operations (i.e., the space shuttle and the International Space Station) was reduced by $168 million in FY2006, and by $160 million in FY2007. The specific amounts identified in the committee-reported bill remained unchanged, and, for FY2006, $8.9 million was specified for the Science and Technology Scholarship Program.

Table 3: Recommended Funding Levels and Budget Structure in H.R. 3070

(in $ millions)

Category	As reported		As passed	
	FY2006	FY2007	FY2006	FY2007
Science, Aeronautics and Education	6,870	7,332	6,870	7,332
Exploration Systems	3,181	3,589	3,844	4,514
Space Operations	6,387	6,008	6,219	5,848
Inspector General	33	34	33	34
Total	**16,471**	**16,962**	**16,966**	**17,727**

Source: H.R. 3070 as reported from the House Science Committee July 18, 2005 (H.Rept. 109-173) and as passed by the House July 22. Column totals may not add due to rounding.

Senate (S. 1281). S. 1281 (S.Rept. 109-108), as reported from the Senate Commerce Committee on July 26, 2005, would provide a five-year (FY2006-2010) authorization for NASA. The authorization for FY2006 and FY2007 is broken down into the three accounts used in NASA's request, but not further allocated to specific programs. For FY2008-2010, only a total for the agency is provided. (See **Table 11** at the end of this report for those figures.)

For FY2006, $16.556 billion is recommended, a $100 million increase above the request. That additional funding, in the Exploration Capabilities account, is for

implementing a section of the bill that pertains to increasing the scientific research conducted aboard the ISS. For FY2007, a $91 million increase is recommended: $17.053 billion. The additional funding similarly is in the Exploration Capabilities account, but there is no language specifying how it should be spent. The bill contains a number of policy provisions, and requires NASA to submit certain reports. These are discussed in subsequent sections of this report as appropriate.

Major NASA Issues

Should NASA Be a "Single Mission" Agency Implementing the Vision for Space Exploration?

On January 14, 2004, President Bush made a major space policy address in which he directed NASA to focus its activities on returning astronauts to the Moon by 2020, and someday sending them to Mars and "worlds beyond." Officially this policy is called the "Vision for Space Exploration," VSE, or simply "the Vision." CRS Report RS21720 discusses the Vision in more detail.

A key question is whether the Vision should be NASA's single focus, which could be a de facto result of the President's decision to fund the Vision by redirecting funds from NASA's other activities, instead of adding substantial new money. Programs throughout the agency are being affected. The space shuttle and U.S. use of the International Space Station (ISS)[8] would end earlier than anticipated. NASA has split its activities into those that are "Vision-related" and those that are not. Those that are not — aeronautics, earth science, and certain space science disciplines — apparently would bear the brunt of cutbacks as NASA "transforms" itself into an agency focused on achieving the goals set forth by President Bush. Related personnel cutbacks are anticipated. However, funding for individual Vision-related projects is not secure either, as NASA Administrator Griffin shifts money from some programs (such as Project Prometheus) into accelerating development of others (notably the Crew Exploration Vehicle).[9]

Congress is debating whether to adopt the President's Vision as announced, or to modify it. At an April 28, 2005 hearing on NASA's earth science program, House Science Committee Chairman Sherwood Boehlert cautioned that he was "somewhat concerned that NASA is being viewed by some as almost a single-mission agency, and it's much more than a single-mission agency, and I'm proud to identify with the

---

[8] The International Space Station is being built as a partnership with Canada, Russia, Japan, and 10 European countries. Although NASA now plans to complete its use of the ISS by FY2017, the other partners could continue to use it. The future of the ISS is discussed later in this report.

[9] It should be noted that some of the funding changes in NASA's FY2005 budget that are negatively impacting certain science programs are not due to the Vision, as sometimes suggested in press accounts, but to funding requirements for returning the shuttle to flight status, for congressionally-related items (including $291 million for a mission to service the Hubble Space Telescope), and for coping with cost growth in existing science programs.

various missions of NASA, including the President's Vision for Space Exploration."[10] (See below for more on Congress' deliberations.)

Dr. Griffin testified at his April 2005 confirmation hearing that NASA pursued a broad range of activities during the Apollo program in the 1960s and early 1970s, and sees no reason the agency cannot do so while implementing the Vision.[11] (Appendix B provides a summary comparison of NASA's human space flight, robotic space flight, and aeronautics activities by decade.) He concluded that the total amount of NASA funding is not the problem, pointing out that NASA received approximately the same amount of money in its first 16 years as it has in the past 16 years (adjusted for inflation). Instead, he said, it is a matter of setting priorities.

Key Features of the Vision. Under the Vision as delineated in January 2004, NASA would terminate the shuttle program in 2010 when construction of the International Space Station (ISS) is completed, instead of operating the shuttle until 2015 or beyond as planned prior to the *Columbia* tragedy. The scientific research program aboard the ISS would be restructured to support only research associated with achieving the Vision instead of the broadly-based program that was planned. NASA would end its use of ISS by FY2017 instead of using it for at least 10 years after assembly is completed, as previously planned. President Bush directed NASA to build a Crew Exploration Vehicle (CEV), with a demonstration flight by 2008, and an operational capability to low Earth orbit no later than 2014. Its primary purpose is transporting astronauts to and from the Moon. NASA also would build robotic probes as "trailblazers" for the astronauts, and launch other robotic missions to explore the solar system and the universe, including new space telescopes. The President invited other countries to join in the initiative.

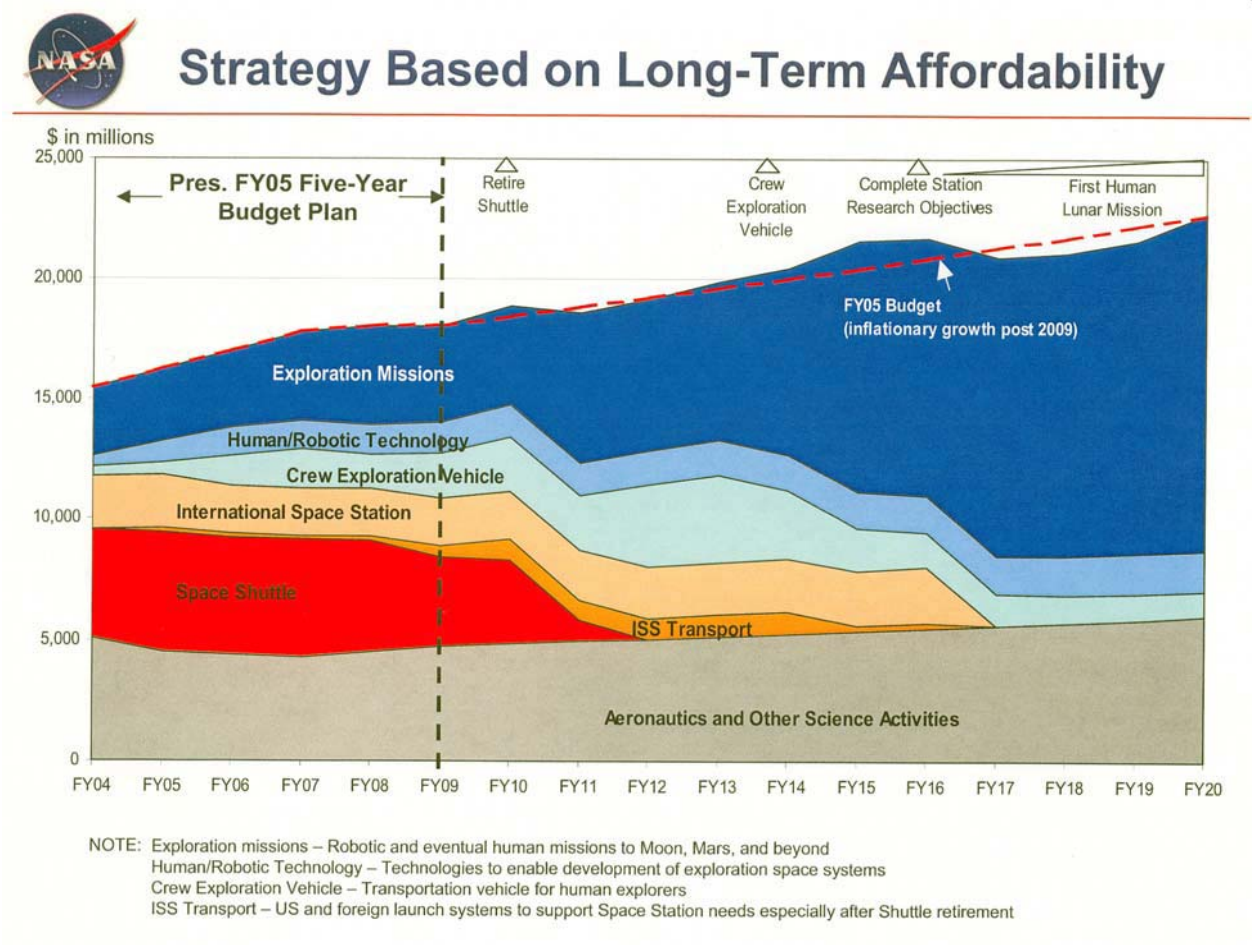
One of the first questions raised by the Vision is whether or not the United States can afford it. Initially, the President and NASA did not provide cost estimates for achieving the goals, only budget estimates for FY2005-FY2009, and a "sand chart" of budget projections through FY2020 (see **Figure 4**). The sand chart showed a NASA budget that would increase approximately 5% each year for FY2005-2007, less than 1% in FY2008 and 2009, and remain roughly level with inflation (approximately 2%) beyond FY2009. NASA officials said the intent of the chart was to demonstrate there was no "balloon" in funding past FY2009. The total amount of funding for the Vision represented in the chart appears to be $150-170 billion. Taking most of the requisite funds from other NASA programs instead of adding new money for the agency may mitigate concerns that the Vision could increase the deficit or detract from other national priorities. But it raises issues about the impact on those other NASA programs, and whether the level of funding is adequate to achieve the goals.

---

[10] House Science Committee hearing on NASA's Earth science program, April 28, 2005. Transcript provided by Federal Document Clearing House (via Factiva).

[11] Dr. Michael Griffin, testimony before the Senate Commerce, Science, and Transportation Committee, April 12, 2005. Transcript by Federal Document Clearing House (via Factiva).

Figure 4. NASA's "Sand Chart" of Projected Budget Authority



In late February 2004, NASA released a cost estimate for landing a crew on the Moon in 2020 — $64 billion (in FY2003 dollars). It consisted of $24 billion (FY2004-2020) to build and operate the Crew Exploration Vehicle; and $40 billion (FY2011-2020) to build the lunar lander portion of that vehicle, a new launch vehicle, and operations. The estimate does not include the cost of robotic missions. NASA did not provide an estimate for sending astronauts to Mars.

Whatever the total cost, the question remains as to whether NASA's annual budget is sufficient to support implementation of the Vision. As noted, NASA's request for FY2006 is less than what the White House projected last year, so the Vision did not survive even its first year of priority setting within the total national budget. Some critics assert that the Vision is more about ending NASA programs than setting the nation on a bold path towards the future. Veteran space commentator John Pike, who operates the globalsecurity.org website, called the Vision "a roadmap for the quiet and orderly phase-out of manned space flight."[12]

Personnel Impacts. Another aspect of the Vision is its effect on NASA's workforce. NASA's FY2006 budget justification, which includes projections for the following four years (i.e., though 2010), assumes that the agency will cut about 2,500 civil service jobs by the end of FY2006. The agency is offering buy-outs and other incentives to encourage staff in certain disciplines to leave, but to date these efforts have not achieved their targets. NASA officials explain that everyone who currently is employed by NASA is funded through the end of FY2006.

As discussed below in the section on the future of the aeronautics program, many of the personnel cuts are expected in the aeronautics field, where significant funding cutbacks are being proposed because aeronautics is not considered to be a Vision-related activity. Four of NASA's field centers focus primarily on aeronautics research — Langley, Glenn, Ames, and Dryden — and are expected to bear the brunt of the personnel cuts. Dr. Griffin has been visiting each NASA center, reassuring workers that the centers themselves will not be closed, but cautioning that workforce changes are inevitable as NASA shifts its focus to implementing the Vision.

Congressional Reaction. As noted, House Science Committee Chairman Boehlert has expressed concern that NASA not become a single mission agency. Science Committee Ranking Democrat Bart Gordon similarly has said that he strongly supports exploration, but "NASA is headed for a potential train wreck as it puts all its eggs in the exploration basket at a time when deficit concerns are going to keep squeezing discretionary spending."[13] He added that "cannibalizing NASA's science and aeronautics programs to fund the exploration initiative will further erode the base of support for NASA in Congress."

As discussed below (see the **FY2005 Budget** subsection), although Congress appropriated funds for the Vision in FY2005, conferees on the appropriations bill

---

[12] Quoted in: Jeffrey F. Bell. The Bush Space Initiative: Fiscal Nightmare or... Fiscal Nightmare? SpaceDaily, March 17, 2004.

[13] Representative Bart Gordon, February 17, 2005 press release [http://www.house.gov/science_democrats/releases/05feb17.htm]

emphasized that it was not an endorsement of the plan. At the February 17, 2005 hearing, Chairman Boehlert made the point that "Congress has never endorsed — in fact, has never discussed — the Vision. What we did do ... is provide the money to enable NASA to continue planning..., but the truly critical spending commitments start is fiscal year '06, so this year is when we must have the debate."[14]

All of the pending NASA funding bills express support for the goals enunciated in the Vision specifically or generally, but they also call for NASA to continue to have a balanced set of programs in science, aeronautics, and exploration.

The House Appropriations Committee report said that it was concerned about maintaining the nation's leadership in science and technology, including in aeronautics. "However, given the serious nature of the budget deficit facing the nation the Committee was forced to make a number of difficult choices in allocating the scarce resources available to NASA and has proposed what it believes is a more balanced budget that both supports the new vision but does not abandon NASA's other core functions." (H.Rept. 109-118, p. 102).

The Senate Appropriations Committee called on NASA to lay the groundwork for implementing the Vision, but added that it is "concerned that NASA will neglect areas that will only tangentially benefit from, or that do not fit within, the proposed vision." The report added that the committee "is concerned that the strong, balanced science program that has served the Nation so successfully for many years could be left behind instead of being nurtured and sustained..." (S.Rept. 109-88, p. 89)

The House Science Committee's report said that the committee "expects NASA to continue to support productive programs in human space flight, aeronautics and science, including space science, earth science, and microgravity. ...[E]ach must be evaluated on its own merits. For that reason, this Act directs NASA to move ahead with the President's Vision for Human Space Exploration, while coming up with separate "visions" to guide the other NASA programs. The Committee is pleased with Administrator Griffin's commitment to operate NASA as a multi-mission agency." (H.Rept. 109-173, pp. 45-46.)

The Senate Commerce, Science, and Transportation Committee's report notes that the bill provides authority and policy guidance for implementing the Vision "in a manner that maximizes the use of the Nation's previous investments in civil space programs and the resulting wealth of expertise and proven technologies. ... The bill would also ensure that an appropriate balance is maintained among NASA's important missions of exploration, space operations, aeronautics research, and science. (S.Rept. 109-108, p. 2.) The Senate authorization bill has a strong focus on utilizing the International Space Station for the broadly based research agenda originally planned, rather than the narrower objectives it would serve under the Vision, and on retaining the space shuttle until a replacement vehicle is available, rather than terminating the shuttle in 2010.

---

[14] Representative Sherwood Boehlert. Opening statement, hearing on NASA's FY2006 budget request [http://www.house.gov/science/hearings/full05/feb17/February172005.htm], February 17, 2005.

FY2005 Budget. For FY2005, Congress appropriated a total for NASA that was quite close to its requested amount: $16.196 billion (including the hurricane supplemental and adjusted for the across-the-board rescission) versus the $16.244 billion requested.[15] House Majority Leader DeLay is widely credited with winning that funding level for NASA.[16] Many commentators concluded the funding level was a sign of congressional support for the Vision. However, conferees on the Consolidated Appropriations Act explicitly stated that although they were appropriating substantial funds for the Vision, "to date there has been no substantive Congressional action endorsing this initiative." (H.Rept. 108-792, p. 1599). They called on the House and Senate authorizing committees to provide guidance and authorization for the effort. Thus, the FY2005 funding level is not necessarily a sign of congressional support. The conferees made the following comments vis a vis the Vision:

- They directed NASA to include in all future budget justifications the phase-out schedules for programs that will be terminated in order to fund the Vision.

- They directed NASA to forward a comprehensive package of authorization legislation for consideration by the 109th Congress.

- They were concerned that NASA was not giving adequate attention to the heavy lift launch requirements of the Vision and directed NASA to report to the appropriations committees within six months of the bill's enactment regarding those needs and how to meet them.

- They were concerned that initial planning for the CEV is insufficient, and directed NASA to provide the appropriations committees with a report detailing the criteria and developmental goals the CEV must meet, and other information. They cautioned NASA not to repeat the mistakes of the space station program, "where poor management and lack of independent oversight resulted in major cost overruns." They directed NASA to identify "an independent oversight committee capable of examining the design, technology readiness, and most importantly the cost estimates for the CEV." That committee is to report to the NASA Administrator and the appropriations committees on its findings and recommendations.

FY2006 Budget Request. As noted, the requested increase in NASA's FY2006 budget is substantially less than was forecast by the White House last year. It is either 2.4% more, or 1.6% more, than the FY2005 appropriated level depending on whether the emergency supplemental for hurricane relief is included, instead of 4.7% more as had been projected. Some therefore view the FY2006 request as an indication of soft support from the White House for implementing the Vision.

---

[15] For action on NASA's FY2005 budget request, see CRS Report RL32676.

[16] For example, see Tax Record Spat Slows Omnibus Spending Vote in Senate, Congress Daily PM, November 20, 2004, (Special Edition).

Within NASA's total budget request, what constitutes funding for the "Vision" is open to interpretation. The entire NASA budget is labeled "Exploration Vision," but a FY2006 NASA budget chart (reproduced as **Table 4**) divides the request into three categories: "exploration-specific," "shuttle & space station," and "earth science, aero, & other." Some may consider the Vision funding as that contained in the "exploration-specific" category. Others may add funding for the space shuttle and space station, since those are often described as the first steps in the Vision. Alternatively, funding specifically for the Exploration Systems Mission Directorate (ESMD, see **Table 2**) could be defined as funding for the Vision

The House Appropriations Committee cut $50 million from research and technology accounts associated with the Vision, but approved the rest of the funding. The Senate Appropriations Committee reduced NASA's overall funding (described earlier) but did not specify where all of the cuts would be made. Funding for specific programs is not identified in the pending Senate authorization bill.

As discussed earlier, H.R. 3070, the House version of the authorization bill, as reported from committee (H.Rept. 109-173), creates a separate budget account for Exploration Systems within NASA's budget structure. The amount recommended for FY2006 is $3.181 billion, $16 million more than NASA requested for Exploration Systems. For FY2007, the committee recommended $3.589 billion, $118 million more than projected in the FY2006 NASA budget documents for Exploration Systems. As discussed earlier, the programs that comprise "Exploration Systems" in the House bill are different than the NASA request, so direct comparisons cannot be made.

The House-passed version of H.R. 3070 also prohibits NASA from implementing any Reductions in Force (RIFs) or other involuntary separations (other than for cause) before February 16, 2007. It further prohibits buyouts until 60 days after NASA transmits to Congress a human capital strategy specified in the bill. What impact these restrictions would have on NASA's budget is unclear. (The House substantially increased the authorized funding level for NASA both for FY2006 and FY2007 as shown in Table 3.)

Table 4. Breakdown of NASA's FY2004-2010 Budget As Exploration-Specific, Shuttle & Station, and Other

(In $ Billions)

	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
Robotic Exploration	**2.7**	**2.8**	**2.8**	**3.3**	**3.8**	**3.9**	**3.9**
Solar System Exploration	*1.9*	*1.9*	*1.9*	*2.3*	*2.8*	*3.0*	*3.1*
*The Universe (Origins-Related)**	*0.8*	*0.9*	*0.9*	*1.0*	*0.9*	*0.9*	*0.8*
Human Exploration	**0.9**	**0.5**	**1.1**	**1.6**	**1.5**	**2.0**	**2.5**
Constellation Systems	*0.9*	*0.5*	*1.1*	*1.6*	*1.5*	*2.0*	*2.5*
Exploration Technology	**1.7**	**2.2**	**2.0**	**2.1**	**2.3**	**2.5**	**2.7**
Exploration Systems Research & Technology	*0.7*	*0.7*	*0.9*	*0.9*	*1.0*	*1.1*	*1.1*
Human Systems Research & Technology	*1.0*	*1.0*	*0.8*	*0.8*	*0.8*	*0.8*	*0.8*
Prometheus Nuclear Science & Technology	*0.0*	*0.4*	*0.3*	*0.4*	*0.5*	*0.6*	*0.8*
Subtotal: Exploration-Specific	**5.3**	**5.5**	**6.0**	**7.0**	**7.6**	**8.4**	**9.0**
Space Shuttle	**4.1**	**4.7**	**4.5**	**4.2**	**3.9**	**2.8**	**2.4**
International Space Station	**1.4**	**1.6**	**1.7**	**1.7**	**1.6**	**1.7**	**1.7**
ISS Cargo & Crew	**0.0**	**0.1**	**0.2**	**0.2**	**0.2**	**0.5**	**0.7**
Subtotal: Shuttle & Station	**5.4**	**6.3**	**6.4**	**6.0**	**5.7**	**5.0**	**4.8**

	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
Aeronautics	**1.1**	**0.9**	**0.9**	**0.7**	**0.7**	**0.7**	**0.7**
Earth Sun Systems**	**2.3**	**2.2**	**2.1**	**2.1**	**2.1**	**2.4**	**2.3**
The Universe (SEU-Related)*	**0.6**	**0.6**	**0.6**	**0.6**	**0.6**	**0.6**	**0.6**
Education	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**
Space and Flight Support	**0.5**	**0.5**	**0.4**	**0.4**	**0.4**	**0.4**	**0.4**
Inspector General	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Subtotal: Earth Science, Aero & Others	**4.7**	**4.4**	**4.1**	**3.9**	**4.0**	**4.3**	**4.2**
Total	**15.4**	**16.2**	**16.5**	**16.9**	**17.3**	**17.7**	**18.0**

Source: NASA table, entitled "Budget for Exploration Vision," provided in a February 10, 2005 briefing on the FY2006 budget request FY2004 is actual; FY2005 is from the December 23, 2004 Initial Operating Plan; FY2006 is the requested level; FY2007-2010 are projections. "Total" was added by CRS. The NASA table did not provide an explanation for why Inspector General funding is listed as zero each year. Typically it is $30-35 million per year.

*Notes on the NASA table explain that the category "Universe (Origins-related)" includes Navigator (a suite of programs including the Space Interferometry Mission and the Terrestrial Planet Finder), Webb Space Telescope, Hubble Space Telescope, the airplane-based SOFIA program (Stratospheric Observatory for Infrared Astronomy), and Discovery programs. "Universe (SEU-related)" includes GLAST (Gamma Ray Large Area Telescope), the Explorer series, ISSC (International Space Science Collaboration), Beyond Einstein, and Universe research. SEU means Structure and Evolution of the Universe, one of the Science themes previously identified in the space science area. For information on these programs, see [http://science.hq.nasa.gov/missions/index.html].

** Earth Sun Systems includes the former Earth Science program, and the former Sun-Earth Systems program (including solar-terrestrial physics projects such as Living with a Star).

Dr. Griffin's Proposed Changes. As noted above, Dr. Griffin testified to the Senate Appropriations CJS Subcommittee in May 2005 that NASA does not have sufficient money to fund all the programs it has on its plate for FY2005, and priorities must be set. Dr. Griffin's chief priorities are returning the shuttle to flight and making each flight as safe as possible, complete construction of the space station by 2010, terminate the shuttle in 2010, and accelerate the development of the Crew Exploration Vehicle (CEV) to minimize the gap between when the shuttle ends and the CEV is available. These priorities are affecting spending plans for FY2005 and FY2006.

- The **Crew Exploration Vehicle (CEV)** and a launch vehicle for it — the Crew Launch Vehicle (CLV) — have become the major focus of the Exploration Systems Mission Directorate (ESMD). They are both funded under "Constellation Systems" within ESMD. Dr. Griffin has stated repeatedly that he wants to close the gap between when the space shuttle will be terminated (2010) and when the CEV becomes available. He also has added servicing the International Space Station to the CEV's requirements. Previously, NASA officials insisted that the CEV's mission was to take astronauts to and from the Moon. They would not commit to its use as a ferry to the ISS, in order to keep the CEV design focused on the lunar transportation requirement. Instead of looking for new concepts for the CEV — which might be expensive and take time to develop — Dr. Griffin emphasizes that it should be simple and straightforward, and therefore not require significant development time. He has decided that instead of funding two contractors with competing designs through 2008, as originally planned, the agency will choose a single contractor in 2006. Dr. Griffin estimates that "downselecting" to one contractor that early could save $1 billion. In the near term, however, additional funds are needed. The FY2006 budget amendment submitted on July 15, 2005 shifts $292 million into CEV/CLV from other ESMD activities. The following reductions are specified: $122 million from the $919 million requested for Exploration Systems Research and Technology; $140 million from the $320 million requested for Project Prometheus (see below); and $30 million from the $807 million requested for Human Systems Research and Technology (see Biological and Physical Research, below).

- **Project Prometheus** is a program to develop new nuclear power and propulsion systems, and was initiated by NASA prior to the Vision speech. NASA initially requested $320 million for FY2006, but the July 15 budget amendment reduced that request by $140 million, with that amount instead shifted into the CEV/CLV effort. The goals of Project Prometheus also are changing. Its original goal was developing Nuclear Electric Propulsion (NEP) and advanced Radioisotope Thermoelectric Generators (RTGs). A robotic probe, the Jupiter Icy Moons Orbiter (JIMO), which was designed to study three of Jupiter's moons, was to be the first mission to use these new systems. RTGs have been used by NASA since the 1960s to supply

power for spacecraft systems and experiments on probes that travel so far from the Sun that solar energy-based systems are impractical. RTGs also can be used for spacecraft that land on surfaces where they will experience "night" for long periods. NASA has not used nuclear propulsion, either NEP or a different type, Nuclear Thermal Propulsion (NTP), in the past, although NASA worked on developing NTP in the 1960s and early 1970s. Dr. Griffin has changed the focus of Project Prometheus to nuclear "surface power" systems (for use on the lunar surface, e.g.), and NTP. Development of NEP is now third on the priority list. JIMO has been indefinitely deferred.

- Funding for **biological and physical research**, including that to be conducted aboard the International Space Station, will be cut further to enable acceleration of the CEV. Previously this research was funded by the Office of Biological and Physical Research (OBPR), which was merged with the Office of Exploration Systems to form the ESMD in August 2004. Activities that were conducted under OBPR are now funded in the "Human Systems Research and Technology" line in ESMD's budget. NASA is developing a revised research plan for the ISS and for supporting the Vision, including identification of what must be done on the ISS versus using ground-based facilities. The details have not been released. Dr. Griffin's announcement that he will tap these research funds to help pay for accelerating the CEV is likely to further affect that research plan. The initial FY2006 request for Human Systems R&D was $807 million. The July 15 budget amendment shifts $30 million of that into the CEV/CLV effort.

- Management responsibility for the **Lunar Reconnaissance Orbiter** (LRO) has been shifted from the Science Mission Directorate to the ESMD. The LRO's purpose is to support the Vision by providing detailed maps of the lunar surface, but since the former Office of Space Science was experienced in developing such probes, it was given management responsibility for LRO originally. Conferees on the FY2005 appropriations bill directed that, because it was being funded by the Office of Space Science, at least 25% of its experiments should focus on science objectives, rather than those associated with the Vision. NASA's decision to move the program into ESMD presumably will makes its purpose and focus clearer. The FY2005 funding level will not change from the $53 million in the December operating plan. (Congress cut funding for the LRO from $70 million to $10 million in FY2005, but NASA nevertheless plans to spend $70 million on it — $17 million that was reprogrammed in FY2004, and $53 million in FY2005). The July 15 budget amendment similarly moves the $135 million requested for the Lunar Robotic Exploration Program in FY2006 from the Science Mission Directorate into ESMD.

What is the Space Shuttle's Future?

The congressional committees that oversee NASA are closely following the agency's efforts to return the space shuttle to flight status following the February 1, 2003 *Columbia* tragedy. Although NASA launched the first of two "Return to Flight" missions — STS-114 — on July 26, 2005, the agency re-grounded the shuttle fleet the next day after discovering problems during that launch that are similar to what led to the loss of *Columbia*. The *Columbia* tragedy, STS-114, and the Return to Flight effort are discussed in CRS Report RS21408. The impact of the STS-114 problems on the future of the shuttle is unclear.

At the same time, there is considerable debate about the shuttle's future in light of President Bush's directive that the shuttle — at least in its current form — be terminated in 2010. Some want the shuttle terminated as soon as possible, either because they consider it unsafe or because they want to use the money now devoted to the shuttle program for other aspects of the Vision instead. Others want to keep the shuttle until the CEV is operational so that the United States is not dependent on Russia for human access to space. A third option is to define precisely how many more shuttle missions are needed, and operate the system until they are completed, whenever that occurs.

Terminating the Shuttle in 2010. All of the remaining shuttle launches currently on the schedule (or "manifest") are for ISS construction and servicing. NASA may restore one other mission contemplated prior to the *Columbia* tragedy — to service the Hubble Space Telescope (addressed elsewhere in this report) — but will not make that decision until after the shuttle successfully returns to flight. Most of the remaining segments of the ISS awaiting launch were designed to be launched only on the shuttle. The shuttle also is used to take crews back and forth. Construction of ISS has been suspended since the *Columbia* accident. NASA and its ISS partners have been keeping two-man crews aboard ISS using Russian spacecraft in the interim.

NASA continues to assess how many shuttle flights are needed to complete the ISS. In early 2005, the estimate was 28, but Dr. Griffin considers only 18 of those 28 to be needed for ISS assembly. The other 10 comprise five for logistics (taking food, water, equipment, etc. to the ISS) and five for utilization (conducting research). He proposes shifting the logistics flights to other launch vehicles, that perhaps could be provided by commercial launch service providers, and to delay NASA's utilization of the ISS. NASA is conducting an assessment of exactly how many more shuttle flights are needed.

NASA's FY2006 request includes budget projections that show the shuttle budget decreasing significantly beginning in FY2008 (see **Table 5**). Whether NASA can succeed in reducing shuttle budgets while maintaining whatever flight rate is needed is uncertain. The board that investigated the *Columbia* tragedy cited budget constraints as a factor.

Table 5. Space Shuttle Projected Funding: FY2005-2010
(in $ millions)

FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
4,543.0	4,530.6	4,172.4	3,865.7	2,815.1	2,319.2

Source: NASA FY2006 budget justification. The FY2005 estimate is from NASA's December 23, 2004 Initial Operating Plan. See the **FY2005 Budget** subsection below for additional changes since then.

Another factor cited by the *Columbia* investigation board was schedule pressure resulting from the ISS assembly schedule. At the time, then-NASA Administrator Sean O'Keefe had set completing a particular phase of ISS construction (called "U.S. Core Complete") by February 2004 as a priority. Today, some worry that setting a firm date of 2010 for completing all shuttle launches is creating an environment similar to that prior to *Columbia*. Dr. Griffin has stated that the shuttle program will end in 2010 even if ISS construction is not completed. NASA is assessing what new launch vehicles may be needed to accomplish the Vision and therefore might be available to service the ISS. (A shuttle derived launch vehicle is one option, as discussed below).

The Senate authorization bill, S. 1281, would direct NASA not to retire the shuttle until a replacement human-rated spacecraft has been demonstrated. By contrast, the House version, H.R. 3070, as introduced and approved at the subcommittee level, directed that the shuttle not be launched after December 31, 2010. However, the Democratic alternative, H.R. 3250, contained language similar to that in the Senate bill. The compromise version of H.R. 3070, as reported from the House Science Committee (H.Rept. 109-173) and passed by the House, is silent on this issue.

Proposal for a "Shuttle-Derived" Launch Vehicle. President Bush's directive that "the shuttle" be terminated in 2010 apparently refers to the shuttle in its current form — a vehicle that takes both crews and cargo into space. The concept of developing a "shuttle-derived" launch vehicle (SDLV, or SDV) has been discussed for many years. The need for a launch vehicle for the new CEV, and a "heavy lift" launch vehicle to support other aspects of the Vision, has reenergized debate about the SDLV. Dr. Griffin is a strong advocate of such a vehicle.

There are several versions of an SDLV under consideration. In one concept, the shuttle's orbiter — the airplane-like section that carries the crew and cargo — would be replaced with a cargo pod, which would be mounted to the side as is the orbiter. Another version would use a single Solid Rocket Booster (the shuttle uses two, one on each side of the orbiter), augmented by a new "upper stage," with a spacecraft on top. One potential use of this vehicle is to launch the new CEV. Still another concept would modify the External Tank (the large cylindrical tank that carries fuel for the orbiter's main engines) and use it alone or in conjunction with SRBs, with a spacecraft on top. These latter two options are called "in line" designs. Advocates argue that the version based on the External Tank could lift approximately 100 tons

of cargo to low Earth orbit (LEO), five times what could be launched with existing versions of the other two major U.S. launch vehicles — Atlas V and Delta IV.[17]

Choosing to build a SDLV might mitigate some of the workforce displacements that would result from terminating the shuttle program in its current form. It also could bring a new launch vehicle into the U.S. fleet at lower cost than developing a new vehicle from scratch. But it is not clear how cost-effective an SDLV would be. How many of the "standing army" of civil servants and contractors, how much of the infrastructure at NASA's Kennedy Space Center, and how much redesign would be needed are under study. Proponents of the Atlas and Delta argue that if NASA used them for the Vision, the cost per launch would go down, making space launches more affordable for DOD and NASA overall. The Atlas and Delta also might be able to be modified to launch heavier payloads.

Boeing manufactures the Delta IV. Lockheed Martin manufactures the Atlas V, as well as the External Tanks for the space shuttle system. The SRBs are manufactured by ATK Thiokol. The United Space Alliance, a 50-50 joint venture between Boeing and Lockheed Martin, is the "single prime contractor" in charge of most ground operations for the existing space shuttle system. The two companies have announced plans to create a similar joint venture, called United Launch Alliance, to market Atlas V and Delta IV to government customers.

Under a national space transportation policy released by the White House in January 2005, NASA, in cooperation with DOD, is to evaluate the relative costs and benefits of EELVs, an SDLV, or a new system.

FY2005 Budget. For FY2005, NASA requested $4.3 billion for the space shuttle program, compared with $4 billion in FY2004. NASA informed Congress in November 2004 that it needed $762 million more in FY2005 for the shuttle program, but a budget amendment was not submitted. Congress appropriated the requested amount, and said that NASA could reprogram funds, or submit a supplemental request if needed. According to NASA briefing charts accompanying its May 10, 2005 operating plan update, funding was reprogrammed as follows: $55 million from the Science Mission Directorate ($20 million from space science, $35 million from earth science); $375.8 million from the Exploration Systems Mission Directorate ($73 million from biological and physical research, $204 million from human and robotic technology, and $98 million from transportation systems); and $331.2 million from the Space Operations Mission Directorate ($160 million from the space station, $170 million from space shuttle upgrades, and $1.2 million from space flight support).

FY2006 Budget Request. NASA's FY2006 request for the shuttle program is $4.5 billion. The House-passed and Senate committee-reported versions of the FY2006 Science, State, Justice, and Commerce appropriations bill (H.R. 2862) fully fund the shuttle for FY2006. The pending authorization bills do not specify how much funding is provided for the shuttle. As noted above, the Senate bill (S. 1281)

---

[17] These two launch vehicles were developed under the Department of Defense's Evolved Expendable Launch Vehicle program and thus are sometimes referred to as "the EELVs."

would direct that the shuttle not be terminated until a replacement is available. The House bill, as passed, is silent on that issue. S. 1281 also would direct NASA to develop an implementation plan for transitioning to a new system for launching crews that uses the shuttle personnel, capabilities, assets, and infrastructure to the fullest extent possible.

What Should Be the U.S. Strategy for the International Space Station Program?

NASA began what is now known as the International Space Station (ISS) program in 1984. Canada, Japan, 10 European countries, and Russia are partners with the United States in building the space station. For more information, see CRS Issue Brief IB93017.

Assembly of the space station was originally intended to be completed by 1994, followed by 30 years of operation during which a wide variety of scientific research would be conducted. The results of that research were expected to have applications on Earth such as new and better pharmaceuticals, metal alloys, and manufacturing processes. The original cost estimate was $8 billion (in FY1984 dollars).

Twenty-one years and approximately $35 billion later, whether those promises will be met is uncertain. Under the Vision, NASA is directed to meet its commitments to the other partners, finish construction in 2010, and complete its utilization of the ISS by FY2017. (The other partners could continue to use it beyond that time.) The President directed that the only research conducted by NASA is that needed to implement the Vision, not the broadly-based program that was planned.

At the same time, it is not clear how NASA astronauts will be able to access the ISS after April 2006. While the shuttle is grounded, two-person crews (one Russian, one American) are being maintained aboard the ISS by using Russian Soyuz spacecraft. A 1996 agreement between NASA and the Russian space agency requires Russia to provide crew transportation and "lifeboat" services[18] to NASA on 11 Soyuz spacecraft at no cost. That agreement would be fulfilled with a Soyuz scheduled for launch in October 2005 and return to Earth in April 2006. Russian officials have made clear that they expect to be paid for any crew transportation or lifeboat services after that point. However, NASA is not permitted to pay Russia for ISS-related services under the Iran Nonproliferation Act (INA, P.L. 106-178). The linkage between the ISS and the INA, and its implications for the future of U.S. access to ISS, are explained in CRS Report RS22072.

The Bush Administration sent a proposed amendment to the INA to the House and Senate on July 12 that would narrow the definition of what payments are prohibited. If adopted, the revised INA would allow NASA to pay Russia for

---

[18] A spacecraft must be docked with the space station at all times so that crews have an emergency escape route in the event of an emergency. The spacecraft that serves that function is called a "lifeboat" or "crew return vehicle" (CRV). NASA terminated its plan to build a CRV in 2002, so Russia's Soyuz spacecraft is the only one available for that duty. For more information, see CRS Issue Brief IB93017.

additional Soyuz missions, for example. An amendment regarding the INA was offered and withdrawn by Representative Rohrabacher at the July 14 markup of H.R. 3070. A committee press release following the markup said that the Science Committee was working with the House International Relations Committee on the INA issue, and quoted Chairman Boehlert as saying that the final bill that is sent to the President for signature must address it, "but I have no idea at this point what that resolution will be."[19]

If the INA is not amended, NASA could have its astronauts on ISS only when the shuttle is docked there. If the shuttle is discontinued in 2010 as currently planned, NASA astronauts would have no access to ISS until the CEV is operational. Even if the INA is amended, some want to continue the shuttle until the CEV is operational to ensure there is no gap in the ability of the United States to place its own astronauts in space. As discussed above, S. 1281 would direct NASA not to terminate the shuttle until a replacement is available.

NASA spends about $2 billion a year on ISS, in addition to the costs of the shuttle program. Some question whether ISS is worth that level of investment considering the modest research opportunities that remain. Others consider fulfilling U.S. commitments to the other ISS partners to be a sufficient rationale for continued U.S. involvement. President Bush pledged to fulfill U.S. commitment to the ISS partners in his Vision speech. Dr. Griffin has reiterated that pledge. How NASA will do that is unclear, since the partners anticipated that the space shuttle, with its large crew and cargo capacity, would be available during the operational phase of the ISS. NASA also was committed to building a Crew Return Vehicle (CRV) that would enable the crew size to increase to at least six. NASA canceled the CRV, then replaced it with another program (called an Orbital Space Plane), which then also was canceled. Dr. Griffin apparently plans to develop a CEV that can be used not only to take crews to and from the Moon, but as a vehicle to transport crews to and from ISS, and remain docked to the ISS for long periods of time, enabling it to serve in a CRV-mode. If that plan proceeds, it may be that the United States once again is building a vehicle to fulfill the CRV function.

Another question is what will happen to the ISS once NASA discontinues its use of the facility. Would it be turned over to the other partners? Would it be privatized? Would it be deorbited? If it remains in orbit under someone else's control, would the United States have any continuing liability if, for example, it made an uncontrolled reentry and impacted people or property on the ground? Or if it collided with another object in space?

FY2005 Budget. Congress did not specify a funding level for the ISS in the FY2005 Consolidated Appropriations Act. The request was $2.412 billion: $1.863 billion for construction and operations, including $140 million in a new "ISS Crew/Cargo Services" line to pay for alternatives to the shuttle for taking crew and cargo to and from ISS; and $549 million for research (included in the request for the

---

[19] Science Committee Unanimously Approves NASA Authorization Bill. House Science Committee press release [http://www.house.gov/science/press/109/109-110.htm], July 14, 2005.

Office of Biological and Physical Research). NASA's December 23, 2004 Initial Operating Plan cut $160 million from ISS construction and operations to help pay for additional costs for returning the space shuttle to flight status. Funding for research also was cut, from the planned $549 million to $382 million (per the December operating plan). Dr. Griffin plans to make additional cuts to the ISS research budget to help pay for accelerating the CEV, but details have not been released.

FY2006 Budget Request. The original FY2006 ISS request was $1.857 billion for construction and operations, including $160 million for ISS Crew/Cargo Services; and $324 million for ISS research. Dr. Griffin indicated in the May 10, 2005 update to the FY2005 operating plan that he is moving the ISS Crew/Cargo Services activity, and associated funding, to the Exploration Systems Mission Directorate (ESMD). The July 15 budget amendment similarly moves the FY2006 ISS Crew/Cargo funding into ESMD, reducing the request for ISS construction and operations commensurately. The budget amendment identifies the FY2006 request for ISS Crew/Cargo Services as $168 million, rather than $160 million as shown in earlier NASA FY2006 budget briefing charts. Thus the revised FY2006 request for ISS construction and operations is $1.689 billion.

The House cut $10 million from ISS construction and operations, and $10 million from ISS Crew/Cargo services program, in the FY2006 SSJC appropriations bill (H.R. 2862). The Senate Appropriations Committee cut all $160 million from ISS Crew/Cargo services because NASA has not spent any of the $98 million provided for FY2005. The Senate Commerce Committee added $100 million for FY2006 for ISS research in its authorization bill (S. 1281, S.Rept. 109-108). That bill also includes extensive language about enhancing the utilization of the ISS, including direction that the U.S. segment of the ISS be established as a "national laboratory." The House-passed version (H.R. 3070, H.Rept. 109-173) would require NASA to allocate 15% of the funds budgeted for ISS research to research that is not directly related to supporting the Vision. It would also direct the Administration to ensure that ISS can be used for a diverse range of microgravity research, be able to support a crew size of at least six persons, support CEV docking and automated docking of other vehicles, and be operated at an appropriate risk level. It also requires a report from NASA on issues such as the ISS research agenda and how the ISS will be completed and serviced.

The FY2000-2002 NASA authorization act (P.L. 106-391) imposed a cost cap on the ISS program (see CRS Issue Brief IB93017 for details). H.R. 3070, as passed by the House, would repeal the cap. S. 1281, as reported, would require NASA to submit a report within six months of enactment that explains the impacts of the space shuttle *Columbia* accident, and NASA's shift to full cost accounting,[20] on the development costs of the ISS, and identifies any statutory changes needed to address those impacts.

---

[20] In full cost accounting, all program costs, including civil service salaries and construction of facilities (CoF), are included in program costs, instead of being identified separately. NASA shifted to full cost accounting in FY2004. For its previous 44 years, NASA had separate account(s) for agency-wide civil service and CoF costs.

Should the Hubble Space Telescope be Serviced?

NASA launched the Hubble Space Telescope in 1990. From the beginning, Hubble was designed to be serviced regularly by astronauts. That design proved fortuitous when it was discovered that Hubble had a defective mirror that produced blurry images. Astronauts on the first servicing mission in 1993 were able to install corrective optics, allowing years of scientific accomplishments and generating widespread scientific and public support. Additional servicing missions were conducted in 1997, 1999, and 2002 to replace aging hardware and install advanced scientific instruments. Two more shuttle missions to Hubble were scheduled: another servicing mission in 2004 (known as SM-4) and a retrieval mission to bring the telescope back to Earth in 2010. In the wake of the *Columbia* tragedy, however, then-NASA Administrator Sean O'Keefe decided in January 2004 not to proceed with either flight. His stated reason was the safety of the shuttle astronauts, but many critics perceived a connection with the new priorities of the Vision for Space Exploration, announced just days before.

The decision to cancel SM-4 brought praise from some, but also considerable congressional and public opposition. The opposition initially focused on efforts to reverse Mr. O'Keefe's decision and proceed with a shuttle mission. Attention soon shifted to robotic options, which dominated the public discussion of Hubble's future throughout most of 2004. In March 2004, Mr. O'Keefe agreed to ask the National Research Council (NRC) to study options for extending Hubble's life, including both shuttle and robotic missions. In December 2004, the final NRC report surprised many by finding it "unlikely that NASA will be able to extend the science life of [Hubble] through robotic servicing." The report recommended a servicing mission by astronauts in the space shuttle, and a robotic mission only for deorbiting the telescope at the end of its useful lifetime.[21] (If left unattended, NASA has estimated that Hubble would make an uncontrolled reentry in about 2012.) Mr. O'Keefe stood by his decision not to proceed with a shuttle servicing mission, and by early 2005, NASA's work on a robotic mission to Hubble was focused on deorbiting it, rather than servicing it.

The confirmation of Michael Griffin as NASA Administrator in April 2005 breathed new life into efforts to service Hubble. At his Senate confirmation hearing on April 12, 2005, Dr. Griffin stated that while he considered robotic servicing infeasible and "would like to take the robotic mission off the plate," he planned to revisit the shuttle servicing option after the shuttle returns to flight. After there have been two successful shuttle flights, NASA would be able to reassess the risks associated with what Dr. Griffin considers "essentially a new vehicle." H.R. 3070 and S. 1281 both call for a shuttle servicing mission after the shuttle returns to flight successfully "unless such a mission would compromise astronaut safety"; they would also require a status report on servicing plans within 60 days of the landing of the second successful RTF flight. Prospects for servicing Hubble became more uncertain

---

[21] National Research Council, *Assessment of Options for Extending the Life of the Hubble Space Telescope*, National Academies Press, 2005. Online at [http://books.nap.edu/catalog/11169.html].

when NASA grounded the shuttle fleet again after problems with the first RTF launch on July 26, 2005.

Congress is debating how to balance the scientific value and public popularity of Hubble with the cost of servicing it, the likely impact of that cost on other NASA astronomy programs, and the remaining safety risks. The NRC report described Hubble as "an enormous scientific success ... the most powerful space astronomical facility ever built ... garnering sustained public attention over its entire lifetime." Without a servicing mission, Hubble would cease scientific operations in about 2008. On the other hand, many expect the cost of a Hubble servicing mission, followed by the cost of operating Hubble for an unknown number of additional years, to be offset by reductions in other NASA astronomy programs. The July 15 budget amendment stated that most of the funding needed to preserve a Hubble servicing option would come from the Terrestrial Planet Finder, a planned future astronomy spacecraft. Considering that Hubble was originally intended to operate only until 2005, and SM-4 was originally intended to extend operations only until 2010, some question whether it makes scientific sense to cut funding for future missions in order to extend the life of Hubble past 2008. And no matter how successfully the shuttle returns to flight, a shuttle mission will always entail some safety risks.

Cost estimates for a Hubble servicing mission vary widely, depending partly on what the mission would include, and partly on how one treats the costs of the shuttle launch. Before the *Columbia* tragedy, Hubble servicing missions were estimated to cost about $100 million each, not including the marginal cost of a shuttle launch. According to a GAO report in November 2004, NASA then estimated the full cost, including all shuttle costs, at between $1.7 billion and $2.4 billion; GAO considered this estimate "not yet definitive."[22]

FY2005 Budget. The FY2005 budget was released shortly after Mr. O'Keefe's first announcement that the shuttle would not fly to Hubble. At that time, NASA intended to cancel the 2004 servicing mission entirely, and was only in the earliest stages of studying the possibility of robotic deorbiting. For this reason, the potential costs of servicing and deorbiting were not included in the FY2005 request. Most of the $130.1 million requested for Hubble was for data analysis. The FY2005 appropriations conference agreement was written before the release of the NRC report, at a time when the debate was focused on the robotic option. It designated $291 million for development of a Hubble servicing mission, but it did not specify where NASA should make the offsetting reductions.

NASA's initial operating plan for FY2005, released after the NRC report but before the appointment of Administrator Griffin, reflected $175 million for development of Hubble servicing and deorbiting missions, with the remainder of the $291 million to be determined after a design review in March 2005. The May 2005 update to the operating plan, released after Dr. Griffin's announcement that a shuttle servicing mission will be reassessed after the shuttle completes its Return to Flight

---

[22] Government Accountability Office, *Space Shuttle: Costs of Hubble Servicing Mission and Implementation of Safety Recommendations Not Yet Definitive*, GAO-05-34, November 2004.

missions, reflected the full $291 million. To fund the difference, NASA has postponed two other astronomy missions — the Terrestrial Planet Finder and the Space Interferometry Mission — and reduced funding for Mars exploration.

FY2006 Budget Request. In the original FY2006 budget, NASA requested $190.7 million for Hubble, including funds for development of a deorbit mission, but no funds for a servicing mission. The July 15 budget amendment requested $30 million to preserve the option of a Hubble servicing mission. If a decision is made to proceed with a servicing mission, and additional funds are needed for it during FY2006, there are three ways to incorporate them into the budget process: (a) NASA could submit an additional amendment to its FY2006 budget; (b) Congress could appropriate funds without an explicit request; or (c) NASA could reallocate funding from other activities via the operating plan process.

The House-passed appropriations bill, H.R. 2862, did not specify a funding level for Hubble, although report language applauded Dr. Griffin's commitment to reassess SM-4. The version reported by the Senate Appropriations Committee recommended a $250 million increase, pending the Administrator's reassessment and final decision. The House-passed authorization bill, H.R. 3070, would authorize $150 million in FY2006 for a Hubble servicing mission. The Senate-reported authorization bill, S. 1281, would not specify a funding level for Hubble.

What is the Future of NASA's Aeronautics Program?

Aeronautics R&D has a long history of government involvement, starting in 1915 with the creation of the National Advisory Committee for Aeronautics (NACA). NASA was established in 1958 using NACA as its nucleus, and NACA's research centers were transferred to the new agency. Although NASA is better known for its space programs, supporters note that aeronautics is "the first A in NASA."

For several years, however, aeronautics advocates have failed to halt a multi-year slide in funding. NASA's budget for aeronautics was cut by about one-third in the late 1990s, with the termination of programs in high-speed research and advanced subsonic technology. In 2003, NASA's move to full-cost accounting heightened funding concerns, because research facilities such as wind tunnels play an especially large role in the aeronautics program.[23] In 2004, when the President announced the Vision for Space Exploration, many foresaw that new spending priorities would increase the pressure on aeronautics further. The FY2006 budget request confirmed that expectation: according to Administrator Griffin, "the nation makes available to us within NASA a certain amount of money ... The fact is that in the President's program going forward, aeronautics is not as high a priority as ... space exploration."[24]

---

[23] Under full-cost accounting, programs must pay for the cost of the facilities they use. Previously, facility costs were budgeted separately. The change therefore meant that the same program activity now appears to require a larger program budget. H.R. 3070 as passed by the House would direct NASA not to seek full cost recovery for its test facilities.

[24] NASA Headquarters, Office of Public Affairs, Press Conference with Administrator Michael Griffin, April 18, 2005. Online at

(continued...)

"Transforming" NASA's Aeronautics Program. As the Vision reduces the priority NASA gives to aeronautics and as total NASA funding for aeronautics declines, the largest element of the aeronautics program, Vehicle Systems, is being "transformed." The FY2006 budget proposes to reduce Vehicle Systems funding by 27% relative to FY2005, place more emphasis on barrier-breaking demonstrations, and focus resources on a smaller number of research areas. NASA describes this new approach as a pilot for transforming the entire Aeronautics Research Mission Directorate. The restructured program consists of four projects: two on noise reduction, one on emissions reduction, and one on unpiloted research aircraft. The topics eliminated include hypersonics, rotorcraft, and ultraefficient engine technology — all of which have received congressional funding increases in past appropriations cycles — as well as most evolutionary, incremental improvements to subsonic aeronautics. The 2003 National Research Council assessment recommended that NASA "pursue more high-risk, high-payoff technologies" and "reduce the number of tasks in its aeronautics technology portfolio," so the transformation is not entirely a result of the Vision, but the elimination of several entire research areas is controversial, especially in the context of substantial, continuing reductions in total funding for the program. The House Appropriations Committee report on H.R. 2862 called for NASA to continue work on hypersonics and rotorcraft and expressed the view that transforming the aeronautics program is premature in light of a May 2005 report by the National Institute of Aerospace and a forthcoming study by the National Research Council (both discussed further below). The Senate committee report on H.R. 2862 referred to the proposed changes in Vehicle Systems as "dismantlement" and directed NASA to "maintain the existing program structure ... along with its people and facilities." The House Science Committee report on H.R. 3070 (H.Rept. 109-173) identified civil supersonic transport, rotorcraft, and hypersonics as initiatives that NASA "may establish."

An especially controversial consequence of the proposed funding reductions is a reduction in staffing levels at NASA centers. According to NASA briefing charts, the reduction in aeronautics funding would mean the elimination of 1,100 civil service jobs at the centers by FY2007. A smaller number of on-site contractor positions would also be eliminated. Most of the affected positions would be at Langley Research Center (in Hampton, VA) and Glenn Research Center (in Cleveland, OH), but Dryden Flight Research Center (in Edwards, CA) and Ames Research Center (in Mountain View, CA) would also be affected. Some aeronautics research facilities at these centers would likely be closed as well, but the affected facilities have not yet been identified. Aeronautics supporters and leaders in the affected communities have expressed alarm at the consequences of these changes, both for aeronautics itself and for the local economies surrounding the centers. Since taking over as NASA Administrator in April 2005, Dr. Griffin has sought to downplay the cuts at the centers. He and other NASA officials insist that the goal is to transform centers, not to close them, and to ensure that the NASA workforce has the mix of skills that is necessary to implement the Vision. On visits to Glenn and Langley in May 2005, Dr. Griffin stated that job losses there will not be as severe as was earlier projected. H.R. 3070 as passed by the House prohibits NASA from implementing reductions in force

---

[24] (...continued)
[http://www.nasa.gov/pdf/113096main_mg_presscon_041805.pdf].

(RIFs) or other involuntary separations (except for cause) until February 16, 2007; this date was October 1, 2006, in the committee-reported bill.

If research areas such as subsonic aeronautics and hypersonics are indeed eliminated from NASA's aeronautics program, the question arises of whether other federal agencies, or the U.S. private sector, will conduct the research that is needed in these areas. A leading justification for federal aeronautics funding has been the economic importance of the U.S. aircraft industry. Supporters often cite increases in European funding for aeronautics R&D as a threat to U.S. competitiveness. NASA's new high-risk, high-payoff approach shifts the program's value to industry towards longer-term needs. Some believe that this is appropriate, and that industry should be responsible for its own short-term R&D, but others argue that aeronautics "requires unique national facilities and world-class researchers that are not resident in any one company" and that "the fruits of this research add to the nation's wealth, not just to that of any individual company."[25] In the past NASA has also stated that it plays "a key role in ... increasing the performance of military aircraft."[26] The FY2006 budget documents no longer mention this goal, and the projects on emissions reduction, noise reduction, and research aircraft that remain in the Vehicle Systems program seem to have little direct application to military needs. The Air Force, Navy, and Defense Advanced Research Projects Agency have aeronautics R&D programs, particularly in the area of hypersonics. These Defense Department programs tend to focus on specific military missions, such as rapid long-range strike, so they may not address all aspects of the field. On the other hand, much of their work has a long enough time horizon that it can be applied quite generally. A concern that has not yet been resolved is how Defense Department and industrial users of NASA aeronautics facilities, such as high-speed wind tunnels, will be affected by possible facility closures. H.R. 3070 as passed by the House would call for an independent review of NASA test facilities and would prohibit closures until completion of that review.

A National Aeronautics Policy. Supporters and critics alike have long argued that NASA's aeronautics program needs a clearer vision of its goals and direction. In February 2001, NASA sought to answer this criticism in *The NASA Aeronautics Blueprint: Toward a Bold New Era in Aviation*.[27] November 2002 brought recommendations on aeronautics from the congressionally established Commission on the Future of the United States Aerospace Industry.[28] In November 2003, the National Research Council published *An Assessment of NASA's Aeronautics Technology Programs*.[29] In May 2005, the National Institute of Aerospace released a congressionally requested five-year plan for U.S. aeronautics research, *Responding*

---

[25] National Institute of Aerospace, Responding to the Call: Aviation Plan for American Leadership.

[26] FY2005 NASA budget request.

[27] [http://www.aerospace.nasa.gov/aboutus/tf/aero_blueprint/cover.html]

[28] [http://www.ita.doc.gov/td/aerospace/aerospacecommission/aerospacecommission.htm]

[29] [http://books.nap.edu/html/atp/0309091195.pdf]

to the Call: Aviation Plan for American Leadership.[30] The National Research Council is undertaking another study, to be completed in late 2006, that will "assess and develop options for a national policy in aeronautics," "develop a course of action to guide the federal government's investment and role in aeronautics," and "provide specific guidance on how to disseminate whatever federal resources may be allocated for aeronautics research."[31] Despite all these efforts, there is still no consensus view of NASA's role in aeronautics.

Three of the pending NASA funding bills — H.R. 2862 and H.R. 3070 as passed by the House, and S. 1281 as reported from the Senate Commerce Committee — would direct the President to develop "a national aeronautics policy ... through 2020." Both House bills focus on NASA: the President would be directed to act "through the [NASA] Administrator ... in consultation with other agencies," and the policy would address how NASA should "coordinate its aeronautics program with other Federal agencies." The Senate bill addresses all federal aeronautics activities equally: the President would be directed to act "through the Director of the Office of Science and Technology Policy, in consultation with NASA and other relevant Federal agencies," and the policy would address the "respective roles and responsibilities of various Federal agencies." H.R. 3070 provides more detail than the other two bills on the issues to be considered, including military and commercial needs and the impact on U.S. industry. It also states that "it shall be the policy of the United States to reaffirm the ... identification of aeronautical research and development as a core mission of NASA." The Senate Appropriations Committee-reported version of H.R. 2862 does not address a new national aeronautics policy in bill language, but the accompanying report supports the concept, and states that any such policy should be based on the May 2005 National Institute of Aerospace report, not on "some new collection effort or study."

FY2005 Budget. Under NASA's May 2005 operating plan, FY2005 funding for aeronautics is $962 million. This total consists of $630 million for the Vehicle Systems program, $183 million for Aviation Safety and Security, and $149 million for Airspace Systems. The original FY2005 appropriation was $919 million, reduced to $906 million by a general rescission. NASA transferred $56 million into the program in its May 2005 operating plan, making the total $962 million, to support the cost of congressionally directed items that were not in the FY2005 budget request.

FY2006 Budget Request. The FY2006 request for aeronautics is $852 million, with a further reduction to $728 million projected for FY2007. The FY2006 total consists of $459 million for Vehicle Systems, $193 million for Aviation Safety and Security, and $200 million for Airspace Systems. The House-passed H.R. 2862 provided $906 million, the same as the FY2005 appropriation before the changes made by the May 2005 operating plan. The Senate report on H.R. 2862 recommended $25 million for hypersonics but did not specify a funding level for aeronautics as a whole. H.R. 3070 as passed by the House would authorize $962 million for FY2006 and $990 million for FY2007. S. 1281 does not specify a funding amount for

---

[30] [http://www.nianet.org/nianews/AviationPlan.php]

[31] [http://www7.nationalacademies.org/aseb/AeroDecadal_Main_Page.html]

aeronautics. The July 15 budget amendment made no changes to the FY2006 request for aeronautics.

NASA's FY2006 Request By Budget Account

NASA's FY2006 budget request has three accounts: Science, Aeronautics, and Exploration (SA&E); Exploration Capabilities; and Inspector General. This section follows the format of the NASA budget as shown in the agency's FY2006 budget estimate. As noted, NASA has changed its budget structure repeatedly over the past several years. For FY2006, the names of the budget accounts remain the same as last year. However, the programs under the two major accounts (SA&E, and Exploration Capabilities) have changed to reflect a new NASA headquarters organization adopted in August 2004. In summary, the Office of Space Science and the Office of Earth Science merged, and are now the Science Mission Directorate (SMD). The Office of Biological and Physical Research and the Office of Exploration merged, and are now the Exploration Systems Mission Directorate (ESMD). The Office of Education was abolished. Its activities are now under a Chief Education Officer. The Office of Space Flight was renamed the Space Operations Mission Directorate (SOMD). The Office of Aeronautics was renamed the Aeronautics Research Mission Directorate (ARMD).

The SA&E account funds the Science Mission Directorate (SMD), the Exploration Systems Mission Director (ESMD), the Aeronautics Research Mission Directorate (ARMD), and Education Programs. The Exploration Capabilities account funds the Space Operations Mission Directorate (SOMD), which includes the International Space Station (ISS), the space shuttle, and space flight operations.

Science, Aeronautics, and Exploration (SA&E)

In the FY2006 budget request, the SA&E account includes the Science Mission Directorate, Exploration Systems Mission Directorate, Aeronautics Research Mission Directorate, and Education Programs. The Science Mission Directorate focuses on increasing human understanding of space and Earth, and makes use of satellites, space probes, and robotic spacecraft to gather and transmit data. The Exploration Systems Mission Directorate is focused on implementing the Vision for Space Exploration, including development of a new Crew Exploration Vehicle to take astronauts to and from the Moon, development of nuclear power and propulsion systems, and biological and physical research, including that to be conducted on the ISS. The Aeronautics Research Mission Directorate contributes to increasing air traffic capacity, reducing the impact of aircraft noise and emissions, and improving aviation safety and security. NASA's education funding is for programs aimed at educating children in elementary and secondary school, as well as university students, in science, mathematics, engineering, and technology.

For FY2006, NASA initially requested $9.661 billion for SA&E, compared with $9.336 billion appropriated for FY2005 (per the December 23, 2004 Initial Operating Plan). That request was increased to $9.829 billion in the July 15 budget amendment, reflecting the shift of $168 million from the Exploration Capabilities account into this

account. The $168 million is for ISS Crew/Cargo Services that had been part of the International Space Station program. That activity now will be part of the Exploration Systems Mission Directorate.

Science. The Science Mission Directorate (SMD) is the merger of the former Office of Space Science (OSS) and Office of Earth Science (OES). Each of those offices was organized by "themes." OSS had six themes (Solar System Exploration, Mars Exploration, Lunar Exploration, Astronomical Search for Origins, Structure and Evolution of the Universe, and Sun-Earth Connections), and OES had two (Earth System Science, and Earth Science Applications). All of those now have been merged into three themes under the new SMD: Solar System Exploration, the Universe, and Earth-Sun System.

Solar System Exploration programs involve sending spacecraft to other planets, the Moon, and other solar system destinations (such as asteroids). They combine the previous themes of Solar System Exploration, Mars Exploration, and Lunar Exploration. Programs in the Universe theme include space-based astronomical observatories such as the Hubble Space Telescope, the Spitzer Space Telescope, the Chandra X-Ray Observatory, and plans for future observatories, as well as planning for studies of dark energy and dark matter, for example. They combine the previous themes of Astronomical Search for Origins, and Structure and Evolution of the Universe. Earth-Sun Systems studies the Earth as a system (such as global climate change) and interactions between the Sun and the Earth (solar terrestrial physics). This theme combines activities previously under the two OES themes, and the Sun-Earth Connections theme that was part of OSS.

Table 6. FY2006 Request for the Science Mission Directorate

(In $ millions)

Theme	FY2005 Estimate*	FY2006 Initial Request	FY2006 Amended Request
Solar System Exploration	1,858.1	1,900.5	1,667.5
The Universe	1,513.2	1,512.2	1,522.2
Earth-Sun System	2,155.2	2,063.6	2,151.9
Total	**5,527.2**	**5,476.3**	**5,341.6**

Source: NASA FY2006 Budget Justification and July 15, 2005 budget amendment.

* NASA's budget justification uses the figures from its Initial Operating Plan, submitted to Congress on Dec. 23, 2004. Updates to that operating plan have been submitted, but are in the format of the FY2005 budget, not FY2006, so cannot be used to update this table.

Budget Amendment Changes. The July 15 FY2006 budget amendment made the following changes to the Science Mission Directorate (SMD). First, are several changes to the Solar System Exploration theme. As announced in the May 10 operating plan update for FY2005, NASA decided to move the Lunar Robotic Exploration Program into the Exploration Systems Mission Directorate (ESMD) since

its primary purpose is to support the Vision for Space Exploration. The FY2006 budget amendment therefore shifts the $135 million requested for the Lunar Reconnaissance Orbiter to ESMD, with a consequent reduction in the Solar System Exploration theme. Next, the budget amendment reduces funding for this theme by $98 million, shifting $88.3 million into the Earth-Sun Systems theme, and $10 million into the Universe theme. According to the budget amendment, the $98 million was "made available" by cancellation or deferral of several robotic Mars exploration programs, while funding also will be added to fund extended operation of the Mars rovers currently on the Martian surface, and to maintain a 2009 launch date for the Mars Science Laboratory [http://marsprogram.jpl.nasa.gov/missions/future/msl.html].

The budget amendment states that the Universe theme would be increased by $10 million, with $30 million provided to preserve the option of a Hubble servicing mission. Most of the funds for the Hubble option would come from funding for a future astronomical observatory called the Terrestrial Planet Finder [http://planetquest.jpl.nasa.gov/TPF/tpf_index.html].

The $88.3 million added for Earth-Sun systems would be allocated to funding the Glory mission (see below), provide additional funding for extending the mission of currently operating satellites, and maintain the launch schedule for the Solar Dynamics Observatory [http://sdo.gsfc.nasa.gov/].

Concerns About NASA's Earth Science Program. The merger of space science and earth science, and cuts to funding for earth science programs as NASA redirects money into implementing the Vision, have raised concerns in the earth science community and Congress. The House Science Committee held a hearing on NASA's earth science program on April 28, 2005. Among the witnesses was Dr. Berrien Moore, the chairman of a National Research Council study that is reviewing NASA's earth sciences program.[32] Dr. Moore warned that the process of building an understanding of the earth system is "at risk of collapse"[33] because of decisions to terminate certain NASA earth science missions. Science Committee Chairman Boehlert said in his opening statement that "The planet that has to matter most to us is the one we live on. You'd think that would go without saying. ... It's great if earth science can contribute to exploration, and greater still if exploration of other planets could teach us more about Earth."[34]

NASA's FY2006 budget justification documents did not allow a comparison of funding for earth science programs between the FY2006 request and prior years because funding for earth science was merged with funding for programs that had been part of the Sun-Earth Connections theme, which was in the former Office of

---

[32] National Academies. National Research Council. Earth Science and Applications from Space: Urgent Needs and Opportunities to Serve the Nation. April 2005. Prepublication Copy. Available at [http://www.nas.edu].

[33] Prepared statement of Dr. Berrien Moore before the House Science Committee, April 28, 2005, p. 2. Available at [http://www.house.gov/science].

[34] Opening statement of Chairman Sherwood Boehlert at House Science Committee hearing on NASA's earth science program, April 28, 2005, p. 1. Available at [http://www.house.gov/science].

Space Science. NASA provides five-year funding projections — called the "budget run-out" — in its annual budget justifications that show the request for the current year plus projections for the next four years. In preparation for the hearing, the Science Committee insisted that NASA provide such a comparison for earth sciences. The funding data were published in the hearing charter (available on the committee's website), and are reproduced in the following table. The data show the budget run-out as it was projected in the FY2004 budget (for FY2004-2008), FY2005 budget (for FY2005-2009), and the current budget (FY2006-2010). The table shows that the earth sciences budget was $1.55 billion in FY2004, $1.49 billion for the current fiscal year (FY2005), and the request for FY2006 is $1.37 billion. Thus, the program experienced a significant cut in FY2005 — a $1 billion cut through the five-year run-out compared with what had been projected in F2004. The cut in the FY2006 request is slightly less. In summary, the cut from FY2004 to FY2005 is 8%; the cut from FY2004-FY2006 is 12%.

Table 7. Changes to Earth Science Budget Run-Out
(in $ billions)

	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
2004 Request	**1.55**	1.53	1.6	1.7	1.73		
2005 Request		**1.49**	1.39	1.37	1.34	1.47	
2006 Request			**1.37**	1.35	1.33	1.47	1.44

Source: House Science Committee. Hearing Charter for April 28, 2005 Hearing on NASA Earth Sciences. Available on the committee's website [http://www.house.gov/science].

Among the earth science programs of particular concern to the earth science community are the Global Precipitation Mission (GPM), Glory, and continuation of data acquired by Landsat satellites. GPM is a follow-on to an existing program (the Tropical Rainfall Mapping Mission) to measure global rainfall. The launch of GPM has been delayed from 2007 to 2010. Glory is intended to study aerosols in the atmosphere and how they affect global climate change. In the original FY2006 budget submission, NASA had decided to cancel development of the Glory spacecraft, but continue development of the sensor, with the hope that it someday would be able to fly on some other spacecraft. The July 15 budget amendment, however, shifts funding into the Glory program to "fully fund a standalone...mission." The portion of the $88.3 million added to Sun-Earth Systems in the budget amendment that will be allocated to Glory was not specified.

NASA launched its first Landsat satellite in 1972. Landsat 5 and Landsat 7 are currently in orbit though both are only partially operational.[35] The earth science community wants to ensure "data continuity" — obtaining similar data over decades

[35] The Landsat satellites are now operated by the U.S. Geological Survey (USGS) in the Department of the Interior.

— for Landsat, but NASA's plans for a follow-on to Landsat 7 have been in flux. NASA hoped that the private sector would build the next satellite and NASA could purchase data on a commercial basis. It received only one bid for that contract, however, and NASA considered it inadequate. NASA's current plan is to build Landsat-type sensors (called Operational Land Imagers, or OLIs) and install them on a different satellite, called NPOESS.[36] Earth scientists are concerned that the NPOESS satellite with the first OLI will not be launched before Landsat 5 and 7 cease operating and data continuity will be lost. They want a "bridge mission" to be launched carrying a Landsat-type sensor to ensure there is no break in data acquisition. H.R. 3070, as reported from the House Science Committee (H.Rept. 109-173), requires the Administrator to seek an independent assessment of the costs and risks associated with placing the OLI on the first NPOESS, versus building a bridge mission and waiting for the second NPOESS to host an OLI.

S. 1281, as reported, directs NASA, in consultation with NOAA and USGS, to submit a plan that ensures the "long-term vitality" of NASA's earth observing system (EOS). EOS is a set of three spacecraft (Terra, Aura, and Aqua) in Earth orbit that are conducting long term global observations of the Earth's surface and atmosphere to better under Earth as a system.

Potential Cuts in Space Science Programs. The Vision incorporates a number of space science disciplines. As described in NASA's FY2005 request, programs to explore other planets and to build and operate space-based observatories such as the Hubble Space Telescope, are Vision-related. However, these programs are feeling the strain of NASA's constrained budget environment as the agency shifts funds to pay for the increasing costs of returning the space shuttle to flight status, to preserve the option of sending a shuttle mission to service the Hubble Space Telescope, to pay for cost growth in other science programs, and to pay for congressionally-directed items. For example, Congress directed in the FY2005 appropriations conference report that NASA spend $291 million on a Hubble servicing mission. NASA must find those funds from within its current budget.

The FY2006 budget run-out for Science Mission Directorate overall is $1 billion less than what had been projected in FY2005. In addition, in the May 10, 2005 operating plan update, Dr. Griffin indicated that he would take funds from future Mars probes (those that were being planned for 2011 and beyond), and from two future space-based observatories — the Terrestrial Planet Finder and the Space Interferometry Mission — to pay for the Hubble Servicing Mission and cost growth in other science programs, such as a Mars probe scheduled for launch in 2005.

NASA also is considering terminating some of its older space science probes even though they are still returning useful data. Considerable concern has been expressed in the space science community at the prospect of turning off the Voyager

---

[36] The National Polar-orbiting Operational Environmental Satellite System (NPOESS) is a joint effort of the National Oceanic and Atmospheric Administration (NOAA), the Department of Defense (DOD), and NASA. NOAA and DOD each operate their own weather satellite systems; NPOESS is the merger of those systems. NASA develops new technology for NPOESS. The first NPOESS is currently scheduled for launch by 2010. Further discussion of NPOESS is outside the scope of this report.

1 and Voyager 2 probes. Launched in 1977, Voyager 1 has just reached the outer edge of the solar system, and Voyager 2 is to do so in a few years. NASA expects to be able to continue to receive data from the probes through 2020, when their power sources are expected to become too weak to send signals back to Earth. NASA explains that there are a total of 13 probes in the Earth-Sun Systems theme that have far exceeded their design lifetimes and are being considered for termination in order to save the $49.6 million requested in the FY2006 budget to continue operating them. The portion of that total for the two Voyager probes is $4.2 million. As Dr. Griffin told the Senate Appropriations CJS subcommittee, NASA cannot afford all of the programs it currently has on its plate, and priorities must be set. The space science community is waiting to see if these probes make the list. Dr. Griffin said at a June 28, 2005 House Science Committee hearing that he thought turning off the Voyager spacecraft was "rather dumb," but that he was awaiting a report from a group that is reviewing the future of all 13 spacecraft before announcing a final decision.[37] The July 15 budget amendment states that some of the $88.3 million added to Earth-Sun systems would be used for extended missions.

H.R. 3070, as reported from the House Science Committee (H.Rept. 109-173), directs NASA to develop a policy to guide earth and space science programs through 2016; requires the National Academy of Sciences to evaluate the performance of each scientific discipline on a certain time schedule; and requires NASA to carry out annual termination reviews for extended missions, and that such a review be made for certain extended missions (including Voyager) within 60 days of enactment, with a report to Congress required 30 days later.

S. 1281 as reported directs NASA to conduct a "rich and vigorous set of science activities." It also directs NASA to assess the cost and benefits of extending the missions of the Voyager spacecraft, and another spacecraft called Ulysses that is studying the Sun.

Exploration Systems. This budget category funds the part of NASA primarily responsible for implementing the "Moon/Mars" portion of the Vision. The Constellation Systems line item funds development of the CEV and a vehicle to launch it — called the Crew Launch Vehicle (CLV). Exploration Systems Research and Technology funds a variety of technology development efforts, including funding for Centennial Challenges, a program through which NASA offers prizes for developing specific technologies. Project Prometheus, which is developing nuclear power and propulsion, is discussed in an earlier section of this report. Human Systems Research and Technology comprises the programs that remain from the previous Office of Biological and Physical Research. It is the budgetary location of funds for research to be performed by NASA aboard the International Space Station, though it also funds ground-based research.

---

[37] Hearing transcript from Federal Document Clearing House, via Factiva.

Table 8. FY2006 Request for Exploration Systems
(in $ millions)

Theme	FY2005 Est.*	FY2006 Initial Request	FY2006 Amended Request
Constellation Systems	526.0	1,120.1	1,412.1
Exploration Systems Research & Technology	722.8	919.2	797.2
Project Prometheus	431.7	319.6	179.6
Human Systems Research & Technology	1,003.9	806.5	776.5
ISS Crew/Cargo Services**	NA	NA	168.4
Lunar Robotic Exploration Program**	NA	NA	135.0
Total	**2,684.5**	**3,165.4**	**3,468.8**

Source: NASA FY2006 Budget Justification and July 15, 2005 budget amendment.
* NASA's budget justification uses the figures from its Initial Operating Plan, submitted to Congress on Dec. 23, 2004. Updates to that operating plan have been submitted, but are in the format of the FY2005 budget, not FY2006, so cannot be used to update this table.
** The July 15 budget amendment moves funding for these two programs into the Exploration Systems Mission Directorate (as discussed earlier in this report), but does not specify if they are now included in one of the four themes identified in the original FY2006 request, or if new themes are created for them. They are shown here as separate line items due to lack of other information to the contrary. NA means Not Applicable.

Congressional action on funding for the Vision is discussed earlier in this report.

Aeronautics Research. NASA's aeronautics research program and its FY2006 budget request are discussed earlier in this report.

Education Programs. Prior to FY2004, NASA's education activities appeared under the budget heading "Academic Programs." NASA reorganized its education activities in 2003, consolidating programs that had been in its Office of Human Resources & Education, and the Office of Equal Opportunity Programs, into a new Office of Education. That office was abolished in the August 2004 reorganization, however. Now, a "Chief Education Officer" oversees these activities. According to NASA current organizational structure, the Chief Education Officer reports to the Chief of Strategic Communications. In addition to the funding identified in the budget under Education Programs, other NASA programs in the various Mission Directorates also fund educational activities. These are not separately identified in NASA's budget justification documents, and therefore are not addressed in this section.

NASA's education programs include a broad array of activities designed to improve science education at all levels — kindergarten through 12th grade (K-12) and higher education. They include programs that directly support student involvement in NASA research, train educators and faculty, develop new educational technologies,

provide NASA resources and materials in support of educational curriculum development, and involve higher education resources and personnel in NASA research efforts. The National Space Grant and Fellowship Program, which funds research, education, and public service projects through university-based Space Grant consortia, is administered through this office. The Space Grant program [http://calspace.ucsd.edu/spacegrant/] was established by Congress in NASA's FY1988 authorization bill (P.L. 100-147). It funds Space Grant Consortia in all 50 states, the District of Columbia, and Puerto Rico, to broaden the base of universities and individuals contributing to and benefitting from aerospace science and technology.

Programs devoted to minority education (the Minority University Research and Education Program — MUREP) focus on expanding participation of historically minority-dominant universities in NASA research efforts. These programs develop opportunities for participation by researchers and students from those institutions in NASA activities. The objective is to expand NASA's research base through continued investment in minority institutions' research and academic infrastructure to contribute to the science, technology, engineering, and mathematics pipeline.

This office also administers NASA's participation in the Experimental Program to Stimulate Competitive Research (EPSCoR). According to its website [http://calspace.ucsd.edu/epscor/], NASA's EPSCoR program targets states of modest research infrastructure with funds to develop a more competitive research base within their member academic institutions. NASA is one of several federal agencies that participate in the EPSCoR program. Among the others are the National Science Foundation,[38] the National Institutes of Health, the Department of Defense, and the Department of Energy.

For FY2006, NASA is requesting $166.9 million for education programs, compared to a FY2005 appropriation of $216.7 million (per the Initial Operating Plan). The difference between the request and last year's appropriation is primarily due to congressionally directed funding for which NASA is not requesting funds in FY2006. The specific amounts for EPSCoR and the Space Grant program are not provided in NASA's budget justification document. The Senate Appropriations Committee specified that within the funds for education, $12 million be for EPSCoR, $29.55 million for the Space Grant program, and $54.233 million for other education-related activities. S. 1281 directs that NASA use appropriated funds to ensure the continuation of the EPSCoR, Space Grant, and NASA Explorer School programs, but does not specify amounts. The bill includes other language supportive of certain education programs. H.R. 3070, as passed, specifies that $24 million in both FY2006 and FY2007 be allocated for the Space Grant program, and in FY2006, $8.9 million be allocated for the Science and Technology Scholarship Program. It also contains a section (Title VI, Subtitle B) regarding other education programs at NASA.

---

[38] NSF's EPSCoR program is described in: CRS Report RL30930, *U.S. National Science Foundation: Experimental Program to Stimulate Competitive Research (EPSCoR),* by Christine Matthews.

Exploration Capabilities

Last year, this budget account included most of the funding related to implementing the Vision, labeled "Exploration Technologies." Those activities now have been moved in the SA&E account under the "Exploration Systems" line. What remains in this budget account is funding for the Space Operations Mission Directorate and its three themes: International Space Station, Space Shuttle, and Space and Flight Support.

The ISS and space shuttle programs are discussed earlier in this report. Space and Flight Support is a budget category that includes funding for space communications, rocket propulsion systems testing, launch services (i.e., acquisition of commercial launch services for NASA payloads that are not launched on NASA's shuttle), and crew health and safety.

Table 9. FY2006 Request for Space Operations
(in $ millions)

Theme	FY2005 Estimate*	FY2006 Initial Request	FY2006 Amended Request
International Space Station**	1,676.3	1,856.7	1,688.3
Space Shuttle†	4,543.0	4,530.6	4,530.6
Space and Flight Support	485.1	375.6	375.6
Total	**6,704.4**	**6,763.0**	**6,594.5**

Source: NASA FY2006 Budget Justification and July 15, 2005 budget amendment.

* NASA's budget justification uses the figures from its Initial Operating Plan, submitted to Congress on Dec. 23, 2004. Updates to that operating plan have been submitted, but are in the format of the FY2005 budget, not FY2006, so cannot be used to update this table.

** Does not include funding for space station research activities, which are included in the Exploration Systems Mission Directorate. At the time of its budget submission, a NASA briefing chart indicated that $382 million in FY2005, and $324 million in FY2006 was for space station research, although those numbers are expected to decrease as the result of later funding decisions.

† The FY2005 estimate in the Initial Operating Plan did not fully fund the $762 million shortfall that NASA identified in November 2004. Additional money subsequently was moved into the FY2005 shuttle account.

The original request for the ISS program included $160 million for ISS Crew/Cargo Services according to NASA briefing charts. This subaccount was created in the FY2005 budget to cover costs associated with obtaining alternative means to the space shuttle for servicing the ISS. Dr. Griffin announced in the May 10, 2005 operating plan that he was shifting responsibility for this program from the Space Operations Mission Directorate to the Exploration Systems Mission Directorate, which is developing a launch vehicle strategy for the future. The July 15 budget amendment similarly shifted the FY2006 requested funding into ESMD, reducing the ISS request (the budget amendment stated that the FY2006 requested level was $168.4 million, not $160 million).

The Senate Appropriations Committee disapproved all $160 million, explaining that NASA had not spent the $98 million provided for FY2005. That amount will be carried over into FY2006, and should be sufficient for any activity initiated in FY2006, according to the committee's report.

Inspector General

In NASA's FY2006 budget documentation, the Office of Inspector General describes its responsibilities as preventing and detecting crime, fraud, waste, abuse and mismanagement, while promoting economy, effectiveness, and efficiency within NASA. The FY2006 request is $32.4 million, an increase of $1.1 million over FY2005. All the pending NASA funding bills recommend the requested amount.

Out-Year Budget Projections

NASA's FY2006 budget estimate contains the out-year budget projections shown in **Table 10**. Such projections are always subject to change, but can be indicative of the direction in which the Bush Administration wants NASA to head. Compared to the projections in the FY2005 budget (see last row), the projected increases in NASA's budget for implementing the Vision for Space Exploration are less in FY2006-2007, and slightly more in FY2008 and FY2009, but still less than the projected rate of inflation (approximately 2%). Also, NASA lists the $126 million in emergency hurricane relief for FY2005 separately from the $16.070 billion provided in the FY2005 Consolidated Appropriations Act. If those figures are added, the increase from FY2005 to FY2006 actually is 1.6%, not 2.4% as shown in this table.

Table 10. FY2006-2010 NASA Funding Projection

(in $ millions)

Budget Account	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
Science, Aeronautics, and Exploration	9,334.7	9,661.0	10,549.8	11,214.6	12,209.6	12,796.1
Science	5,527.2	5,476.3	5,960.3	6,503.4	6,853.0	6,797.6
Exploration Systems	2,684.5	3,165.4	3,707.0	3,825.9	4,473.7	5,125.5
Aeronautics Research	906.2	852.3	727.6	730.6	727.5	717.6
Education Programs	216.7	166.9	154.9	154.7	155.4	155.4
Exploration Capabilities	6,704.4	6,763.0	6,378.6	6,056.7	5,367.1	5,193.8
Space Operations	6,704.4	6,763.0	6,378.6	6,056.7	5,367.1	5,193.8
International Space Station	1,676.3	1,856.7	1,835.3	1,790.9	2,152.3	2,375.5
Space Shuttle	4,543.0	4,530.6	4,172.4	3,865.7	2,815.1	2,419.2
Space and Flight Support	485.1	375.6	370.9	400.0	399.7	399.1
Inspector General	31.3	32.4	33.5	34.6	35.2	37.3
TOTAL	**16,070.4**	**16,456.3**	**16,962.0**	**17,305.9**	**17,611.9**	**18,027.1**
Year to Year Increase (%) Projected in FY2006 Budget		**2.4***	**3.1**	**2.0**	**1.8**	**2.4**
Emergency Hurricane Supplemental	126.0					
GRAND TOTAL	**16,196.4**	**16,456.3**	**16,962.0**	**17,305.9**	**17,611.0**	**18,027.1**
Year to Year Increase (%) Projected in FY2005 Budget	*5.6*	*4.7*	*4.8*	*1.0*	*0.2*	**

Source: NASA FY2006 Budget Justification, p. 1, except that CRS added the last two rows. The Grand Total was calculated by CRS; the Year to Year Increase Projected in the FY2005 Budget is from NASA's FY2005 Budget Justification, p. 1. As noted in NASA's FY2006 Budget Justification, the FY2005 figures in this table are from NASA's Initial Operating Plan, submitted to Congress on December 23, 2004, and are not final.

* As noted in the text of this report, the actual increase from FY2005 to FY2006 is only 1.6% when the $126 million in emergency hurricane relief funds are added to the $16.070 billion provided in the FY2005 Consolidated Appropriations Act.

** The projected budgets are for five years only, so the FY2005 budget did not include a figure for FY2010.

The Senate authorization bill, S. 1281, recommends annual funding for NASA for FY2006-2010. The totals for FY2006 and FY2007 are broken down by account. **Table 11** shows the figures recommended in that bill as reported from committee. The House authorization bill, H.R. 3070, as passed by the House, authorizes funding for FY2006 and FY2007 in a budget structure different from that used in the NASA request (see **Table 3**).

Table 11. Five-Year Funding Recommendations in S. 1281

(In $ millions)

Budget Account	FY2006	FY2007	FY2008*	FY2009*	FY2010*
Science, Aeronautics & Exploration	9,661	10,550			
Exploration Capabilities	6,863	6,470			
Inspector General	32	34			
TOTAL	16,556	17,053	17,470	17,995	18,535

Source: S. 1281. Totals may not add due to rounding.
*Funding for FY2008-2010 was not broken down by account.

Appendix A: Related CRS Reports

General

CRS Issue Brief IB92011, *U.S. Space Programs: Civilian, Military, and Commercial*
CRS Issue Brief IB93017, *Space Stations*
CRS Issue Brief IB93062, *Space Launch Vehicles: Government Requirements, Commercial Competition, and Satellite Exports*

The Vision for Space Exploration

CRS Report RS21720, *Space Exploration: Issues Concerning the "Vision for Space Exploration"*
CRS Report RS21866, *Space Exploration: Report of the Aldridge Commission on Implementation of President Bush's Exploration Initiative*

The *Columbia* Accident and the Space Shuttle Program

CRS Report RS21408, *NASA's Space Shuttle Program: Issues for Congress Related to the Columbia Tragedy and "Return to Flight"*
CRS Report RS21606, *NASA's Space Shuttle Columbia: Synopsis of the Report of the Columbia Accident Investigation Board*

Hubble Space Telescope

CRS Report RS21767, *Hubble Space Telescope: Should NASA Proceed with a Shuttle Servicing Mission?*

Appendix B: Highlights of NASA's Activities: 1958-2004

Time Period	Human Space Flight	Robotic Spacecraft for Space and Earth Science and Applications	Aeronautics
1958-1959	• Adoption of goal to launch people into space: - initiation of Project Mercury and selection of first group of astronauts — the "Mercury 7"	• Launch of first U.S. satellites, including: - Beginning of Explorer series** (which continues today), including Explorer 1, which led to discovery of Van Allen belts of radiation - Beginning of Pioneer series of probes to study Moon, though most of those launched in this era failed	• First flight of rocket-powered X-15 aircraft. The X-15 program produced data on aerodynamic heating, high-temperature materials, reaction controls, and space suits.
1960-1969	• Adoption of 1961 goal announced by President Kennedy to land a man on the Moon and return him safely to Earth by the end of the decade. • Six flights (1961-1963) in Project Mercury: two suborbital, four orbital. The Mercury spacecraft accommodated one astronaut. - Alan Shepard first U.S. astronaut in space (suborbital), 1961 - John Glenn first U.S. astronaut in orbit, 1962 • Ten flights (1965-1966), in Gemini Program, all orbital. The Gemini spacecraft accommodated two astronauts.	• Launches of experimental communications satellites: Echo, and Applications Technology Satellite (ATS) series. (Most civilian communications satellites were and are built and launched by the private sector; NASA's role was R&D). • Launches of experimental weather satellites: TIROS and Nimbus series. (Weather satellite program transferred to what is now NOAA† late in the decade once technology was demonstrated.) • Continued launches of Explorer satellites. • Continued launches of Pioneer series to Moon, including four successes (Pioneer 6-9). • Launches of three other series of probes to fly-by,	• Three X-15 aircraft complete a total of 199 flights, setting records for altitude (67 miles) and speed (Mach 6.7). • Early development of the wingless "lifting body" concept, which later contributed to the design of the space shuttle.

Time Period	Human Space Flight	Robotic Spacecraft for Space and Earth Science and Applications	Aeronautics
	- demonstrated extravehicular activity (EVA, or spacewalks) - demonstrated rendezvous and docking in space - extended duration of human space flight missions to 14 days • First flights in Apollo Program. The Apollo spacecraft accommodated three astronauts. The Apollo Program also involved NASA's development of the Saturn launch vehicle. - 1967 Apollo fire killed three astronauts in pre-launch test - two Apollo missions to earth orbit (Apollo 7 and 9) - two Apollo missions to lunar orbit (Apollo 8 and 10) - two Apollo missions land on Moon (Apollo 11 and Apollo 12)	orbit, or land on the Moon: - nine Rangers (three successful) - seven Surveyors (five successful) - five Lunar Orbiters (all successful) • Launches of seven Mariner probes to Venus or Mars (five successful). • Launches of two spacecraft in Orbiting Astronomical Observatory (OAO) series (one successful). • Launches of six spacecraft in Orbiting Geophysical Observatory (OGO) series (three successful). • Launches of six spacecraft in Orbiting Solar Observatory (OSO) series (five successful).	
1970-1979	• Apollo program continues: - Apollo 13 accident in 1970; crew safely returns to Earth after Service Module explodes enroute to the Moon - four more lunar landings (Apollo 14, 15, 16, 17) - three Apollo missions (Apollo 18-20) canceled due to budget constraints	• Continuation of Mariner series: - Mariner 9, first U.S. probe to orbit Mars (a companion probe, Mariner 8, lost in launch failure) - Mariner 10, first probe to visit both Venus and Mercury. • Continuation of Pioneer series: — Pioneer 10 and 11, first probes to Jupiter and Saturn.	• First flight test of an electronic fly-by-wire control system, replacing hydraulic-mechanical controls to improve safety, maneuverability, and efficiency. • First demonstration of a full

Time Period	Human Space Flight	Robotic Spacecraft for Space and Earth Science and Applications	Aeronautics
	• President Nixon approves development of reusable space transportation system — the Space Shuttle — in 1972. • Skylab space station launched in 1973; three 3-person crews occupy Skylab from 1973-1974 (launched to the space station using Apollo spacecraft). Skylab made an uncontrolled reentry through Earth's atmosphere in 1979, spreading debris on Australia and the Indian Ocean. • U.S.-Soviet Apollo-Soyuz Test Project in 1975, with docking of U.S. Apollo and Soviet Soyuz spacecraft for two days of joint experiments. Last Apollo mission; no more Americans in space until 1981.	— Pioneer Venus 1 and 2 to Venus • Launches of Viking 1 and 2, first U.S. probes to land on Mars, each with a companion orbiter in Martian orbit. • Launches of Voyager 1 (to Jupiter and Saturn) and Voyager 2 (to Jupiter, Saturn, Neptune, and Uranus); today they continue to send data back from their current positions as they head out of the solar system — Voyager 1 is 14 billion kilometers, and Voyager 2 is 11 billion kilometers, from the Sun. • Continued launches of Explorer satellites. • Two more launches in OSO series (both successful). • Two more launches in OAO series (one successful). • Three launches in High Energy Astronomy Observatory (HEAO) series (all successful). • Launches of Landsat 1, 2, and 3 — series of earth orbiting remote sensing satellites (all successful). • Launches of other earth science satellites, including Heat Capacity Mapping Mission (HCMM); and Seasat, which carried a radar for ocean sensing (but failed after 100 days).	"glass cockpit" using electronic instead of electromechanical displays, gauges, and instruments • First flight test of winglets (small wings at the end of each main wing) to reduce aerodynamic drag, improving fuel efficiency and range.
1980-1989	• First decade of Space Shuttle flights; missions included launch of government and commercial satellites, retrieval of malfunctioning satellites, and several flights of "Spacelab" (a shirt-sleeve	• Launch of Earth-orbiting Solar Maximum Mission to study the Sun. • Continued launches of Explorer satellites. • Launch of Magellan probe to Venus.	• Joint NASA-FAA Airborne Wind Shear program initiated in response to multiple fatal accidents.

Time Period	Human Space Flight	Robotic Spacecraft for Space and Earth Science and Applications	Aeronautics
	laboratory, built by Europe, that fits inside the shuttle's cargo bay): - first shuttle flight in April 1981 - total of 24 successful shuttle launches until January 1986 Space Shuttle Challenger tragedy - shuttle returns to flight in September 1988 - six more successful flights through end of 1989 • President Reagan, in 1984, directs NASA to build a permanently occupied space station "within a decade" and to invite other countries to join. Europe, Canada, and Japan do so. Many redesigns and program restructurings because of cost growth; no space station launches during this time period.	• Launch of Galileo probe to Jupiter. • Launches of Landsat 4 and 5 earth remote sensing satellites (both successful). • Launch of other earth science satellites, including Earth Radiation Budget Satellite (ERBS — two more instruments in this series were later launched on NOAA weather satellites).	Wind-shear accidents have since been virtually eliminated for large commercial transports. • National Transonic Facility cryogenic wind tunnel becomes operational. Vehicles subsequently tested include the Boeing 777, space shuttle, and F-18. • National AeroSpace Plane (NASP) program initiated. Developed technologies such as composite airframe materials, but program cancelled in 1994.
1990-1999	• Continued flights of the Space Shuttle: - 64 successful missions during the decade, including nine to visit Russia's Mir space station. Others dedicated to various scientific missions (including use of Spacelab), launching NASA or DOD satellites, and servicing Hubble Space Telescope. • Space station further redesigned and reconfigured: - Russia joins international space station partnership	• Launch of Advanced Communications Technology Satellite (ACTS). • Launch of Polar and Wind spacecraft as part of international program to study solar-terrestrial physics. • Launch of three of four "Great Observatories": Hubble Space Telescope, Compton Gamma Ray Observatory, and Chandra X-Ray Observatory. • Launch of Cassini spacecraft to Saturn.	• First flight test of flight control using only engine thrust (without elevators, rudders, or ailerons) permitting continued operation if main control system fails. • First of 385 research flights on modified F-18 to

Time Period	Human Space Flight	Robotic Spacecraft for Space and Earth Science and Applications	Aeronautics
	in 1993 - first two space station segments launched in 1998; then hiatus (until 2000) while awaiting the next Russian segment to be completed	• Continued launches of Explorer satellites. • Initiation of "Discovery" series of spacecraft, including launches of Near Earth Asteroid Rendezvous (NEAR) mission, Lunar Prospector, and Stardust (to return sample of comet to Earth). • Launch of Deep Space 1 test of ion engines for deep space missions. • Continued launches of Mars probes, including two successful missions in 1996 (Mars Pathfinder, which was part of the Discovery series, and Mars Global Observer), and three failures (Mars Observer in 1993, and Mars Polar Lander and Mars Climate Orbiter in 1999). • Continued launches of earth science satellites, including Upper Atmospheric Research Satellite (UARS), Total Ozone Mapping Spectrometer-Earth Probe (TOMS-EP), TOPEX/Poseidon and QuikSCAT for ocean sensing, and the first of three Earth Observing System (EOS) platforms — Terra. • Launch of Landsat 7††	demonstrate stabilized flight at high angles of attack, improving safety for fighter aircraft during extreme maneuvers. • SR-71 flights investigate how to reduce the intensity of sonic booms.

Time Period	Human Space Flight	Robotic Spacecraft for Space and Earth Science and Applications	Aeronautics
2000-2004	• Continued flights of the Space Shuttle: - 16 successful launches, many associated with construction of the space station, until Space Shuttle Columbia tragedy in February 2003 - Shuttle fleet grounded for 2 ½ years until first Return to Flight mission in July 2005 (STS-114). • Continued space station construction and operation: - "permanent occupancy" begins in November 2000. Two or three astronauts have been aboard the facility since that time on rotating shifts, in addition to visiting crews on U.S. space shuttle or Russian Soyuz spacecraft • President Bush announces "Vision for Space Exploration" in January 2004, directing NASA to return humans to the Moon by 2020 and someday send them to Mars and "worlds beyond."	• Launch of fourth Great Observatory (Spitzer Space Telescope). • Continued launches of Mars probes (including Mars Odyssey orbiter, and Spirit and Opportunity rovers). • Continued launches of Discovery-class missions, including Genesis to return samples of solar wind to Earth, and Messenger to orbit Mercury. • Continued launches of Explorers. • Continued launches of earth science satellites, including EO-1, ICESAT, ocean sensing satellite JASON-1 (a follow on to TOPEX/Poseidon), and final two EOS platforms — Aqua and Aura. • Launch of Gravity-Probe B to test Einstein's general theory of relativity.	• Unpiloted solar-electric research vehicle Helios sets altitude record for propeller-driven aircraft (97,000 feet), with possible applications in ground imaging and atmospheric monitoring or as an alternative to satellites for telecommunications. • X-43A demonstrates air-breathing scramjet engines for hypersonic flight, with sustained speed of Mach 9.6.

Prepared by CRS.

* This table shows illustrative examples of NASA space missions, and is not meant to be comprehensive.

** NASA's Explorer website [http://nssdc.gsfc.nasa.gov/multi/explorer.html] reports that as of March 2000, 78 Explorer satellites had been launched, 74 successfully. Several more have been launched since. These satellites cover a wide range of disciplines, including atmospheric physics, solar-terrestrial physics, and astronomy. The Explorer program was begun by the U.S. Army prior to the creation of NASA. The Army Ballistic Missile Agency (ABMA) developed the

launch vehicle used for the early Explorer launches, and the Army's Jet Propulsion Laboratory built the satellites. ABMA, JPL, and the Explorer program were transferred to NASA upon its creation; but the first five Explorer satellites (three of which were successful), strictly speaking were DOD, not NASA, satellites.

† NOAA is the National Oceanic and Atmospheric Administration, part of the Department of Commerce.

†† After NASA's launch of Landsat 1-5 in the 1970s and 1980s, an attempt was made to privatize the Landsat system. One satellite, Landsat 6, was launched under that privatization program, which was overseen by NOAA, not NASA. That launch failed, and the program was brought back under NASA sponsorship, and NASA launched Landsat 7. Therefore, Landsat 7 is included in this table, while Landsat 6 is not. Landsat 5 and 7 are still operational, and are operated by the U.S. Geological Survey.