

An hourglass-shaped graphic with a globe inside. The top bulb is dark blue, and the bottom bulb is light blue. The globe is centered in the narrow neck of the hourglass. The text is overlaid on this graphic.

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Congressional Research Service

Report RL32676

*The National Aeronautics and Space Administrations
FY2005 Budget Request: Description, Analysis, and Issues
for Congress*

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

December 10, 2004

Abstract. This report discusses the major issues being debated in the context of NASAs FY2005 request for \$16.2 billion, a 5.6% increase over its FY2004 appropriated level of \$15.4 billion. The three most prominent issues are the announcement by President Bush of a new Vision for Space Exploration through which humans would return to the Moon by 2020 and then go on to Mars and world beyond; NASAs preparations for returning the space shuttle to flight status following the February 2003 space shuttle Columbia tragedy; and whether to launch a repair mission to the Hubble Space Telescope.

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Updated December 10, 2004

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

The National Aeronautics and Space Administration's FY2005 Budget Request: Description, Analysis, and Issues for Congress

Summary

For FY2005, NASA requested \$16.244 billion. Congress appropriated \$16.200 billion, or \$16.070 billion when adjusted for the 0.80% across-the-board rescission. NASA's funding is part of the VA-HUD-IA appropriations bill, which is Division I of the FY2005 Consolidated Appropriations Act (P.L. 108-447). The \$16.070 billion is a 4.5% increase over the agency's FY2004 appropriation of \$15.378 billion. Importantly, Congress granted NASA "unrestrained transfer authority" to shift money between its budget accounts, except for certain activities specified in the conference report (H.Rept. 108-792). NASA must notify Congress of its plans for spending the money. Until that notification is submitted, it is not possible to specify how much the agency will spend on any particular program other than the few specified in the conference report.

Separately, NASA received \$126 million in a FY2005 emergency supplemental (P.L. 108-324) for hurricane relief. The Senate Commerce Committee reported a FY2005-FY2009 NASA authorization bill (S. 2541), but there was no floor action. No authorization bill was introduced in the House.

Debate over NASA's FY2005 budget took place as NASA responds to the announcement of new goals for the U.S. space program by President Bush in January 2004, and recovers from the February 2003 space shuttle *Columbia* tragedy. NASA hopes the space shuttle will return to flight in 2005, at which time assembly of the International Space Station (ISS) can resume. Returning the shuttle to flight and completing construction of ISS are the first steps in President Bush's "Vision for Space Exploration" in which NASA will focus its activities on returning humans to the Moon by 2020 and someday sending them to Mars and "worlds beyond." The Vision involves human spaceflights, as well as using robotic spacecraft as trailblazers for human missions and to investigate whether life may exist elsewhere in the universe. President Bush emphasized that achieving these goals is a "journey, not a race." White House and NASA officials stress that the Vision will take many years to accomplish, spanning multiple Congresses and Presidential administrations. Thus, the FY2005 request is the opening of a debate expected to span many budget cycles.

The Bush Administration does not plan to add much funding for NASA to fulfill the Vision. Instead, funding will be redirected from NASA activities not directly related to the Vision, and by terminating the space shuttle and the space station programs earlier than many had expected. That approach to funding the Vision may mitigate concerns about rising deficits or neglecting other national priorities in order to fund the Vision, but it subjects the plan to criticism that the total agency projected funding level is insufficient, and that the plan will preclude other important NASA activities in space science, earth science, and aeronautics. This is the final edition of this report. An abbreviated version is available in CRS Report RS21744, *The National Aeronautics and Space Administration: Overview, FY2005 Budget in Brief, and Key Issues for Congress*, by Marcia S. Smith, Daniel Morgan.

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The National Aeronautics and Space Administration's FY2005 Budget Request: Description, Analysis, and Issues for Congress

Preface

This report discusses the major issues that were debated in the context of NASA's FY2005 request for \$16.2 billion, a 5.6% increase over its FY2004 appropriated level of \$15.4 billion. The three most prominent issues were the announcement by President Bush of a new "Vision for Space Exploration" through which humans would return to the Moon by 2020 and then go on to Mars and "world beyond"; NASA's preparations for returning the space shuttle to flight status following the February 2003 space shuttle *Columbia* tragedy; and whether to launch a repair mission to the Hubble Space Telescope.

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 RS21744, *The National Aeronautics and Space Administration: Overview, FY2005 Budget in Brief, and Key Issues for Congress*, by Marcia Smith and Daniel Morgan.

FY2004 and FY2005 figures cited in this report are from NASA's budget justification documents, available at [<http://www.nasa.gov/about/budget/index.html>]. Program descriptions are condensed from material provided by NASA in that or previous budget estimates, and previous CRS reports in this series. NASA's FY2005 budget was subject to a 0.80% across-the-board rescission. Congress gave NASA, in the words of the conference report (H.R. 4818, H.Rept. 108-782), "unrestrained transfer authority" to shift money between its two major budget accounts. Exceptions were made for a few programs specifically mentioned in the conference report, on which NASA is directed to spend the specified level of funding. Until NASA notifies Congress of its plans to spend the funding, it is not possible to state how much is allocated to NASA's other activities, or how the rescission will be applied. **Thus, this report does not adjust NASA's funding for the rescission, other than at the total agency level.** Where FY2005 funding levels are stated, they are taken directly from the text of the conference report (i.e., prior to the rescission).

NASA has been restructuring both its budget and its headquarters organization over the past several years. The structure of this report and its budget tables follow the format and content of what is presented in NASA's FY2005 budget request documentation. This may not match what appears in congressional reports on NASA's funding measures. Also, an August 2004 NASA reorganization (see

“NASA’s Changing Organizational Structure” below) eliminated three of the program offices identified in the FY2005 budget documents (Earth Science, Biological and Physical Research, and Education). The structure of NASA’s FY2005 budget request, however, relies on the organization as it existed in February 2004 and thus these program offices remain in this report.

Introduction to NASA

NASA was created by the 1958 National Aeronautics and Space Act (P.L. 85-568). 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 opened its doors on October 1, 1958, 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:

- **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;
- **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**, Houston, TX, which also manages NASA activities at the White Sands Test Facility, White Sands, NM;
- **Kennedy Space Center**, 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. Web links to all these field centers can be found at [<http://www.nasa.gov/nasaorgs/index.html>] by clicking on “NASA Sites” on the left menu.

NASA employs approximately 19,000 civil servants (full time equivalents), and 40,000 on-site and near-site support contractors and grantees. For more details on NASA’s workforce, see [<http://nasapeople.nasa.gov/workforce/default.htm>].

NASA is headed by an Administrator. The current Administrator is Mr. Sean O’Keefe, who was confirmed by the Senate on December 20, 2001. Immediately prior to his appointment, he was deputy director of the Office of Management and

Budget (OMB). Mr. O’Keefe is the 10th NASA Administrator. His predecessor was Mr. Daniel Goldin, who held the position for almost 10 years.

NASA’s Changing Organizational Structure

NASA’s organizational structure has changed periodically throughout the agency’s history. Beginning in the 1990s, following initiatives by the Clinton White House and Congress to emphasize stronger strategic planning for, and better management of, government agencies, NASA organized its activities as a set of “Strategic Enterprises” that roughly paralleled its program offices. Initially, there were four: Human Exploration and Development of Space (HEDS), which encompassed activities within NASA’s Office of Space Flight (primarily the space shuttle and the International Space Station) and the Office of Life and Microgravity Sciences (primarily concerned with the health of the astronauts and research that could be conducted on the shuttle and ISS); Space Science (including robotic exploration of the solar system, space telescopes, etc.); Earth Science (spacecraft that study Earth and its climate); and AeroSpace Technology (primarily aeronautics research and efforts to develop new reusable launch vehicles to replace the shuttle). In 2000, then-Administrator Goldin renamed the Office of Life and Microgravity Sciences as the Office of Biological and Physical Research (OBPR) and elevated it to Enterprise status.

Thus, when Mr. O’Keefe became Administrator at the end of 2001, there were five Enterprises: Aerospace Technology, Biological and Physical Research, Earth Science, Human Exploration and Development of Space, and Space Science. In 2003, he created a sixth — Education — and with it, an Office of Education, to consolidate educational activities that had been managed in different parts of the agency. (They were labeled “Academic Programs” in the budget).

In January 2004, following President Bush’s “Vision” speech (see **Major NASA Budget Issues** below), he created a seventh Enterprise by dividing Aerospace Technology into Aeronautics Research and Exploration Systems. The Exploration Systems Enterprise, and its Office of Exploration Systems, is charged with implementing many aspects of the Vision.

The FY2005 budget request, therefore, is based on those seven Enterprises and their associated offices: Aeronautics, Biological and Physical Research, Earth Science, Education, Exploration Systems, Space Flight, and Space Science. For decades, within the space community, NASA’s program offices have been known by and referred to by their mail codes. The Office of Aeronautics as Code R, the Office of Biological and Physical Research as Code U, the Office of Earth Science as Code Y, the Office of Exploration Systems as Code Z, the Office of Space Flight as Code M, the Office of Space Science as Code S, and the Office of Education as Code N.

Effective August 1, 2004, Administrator O’Keefe reorganized NASA again. In a June 24, 2004 press release, Mr. O’Keefe cited the need “to streamline the agency

and position it to better implement the Vision for Space Exploration.”¹ He reduced the number of program offices and Enterprises from seven to four, renamed the remaining Enterprises as “Mission Directorates,” and banished the practice of using mail codes as shorthand.

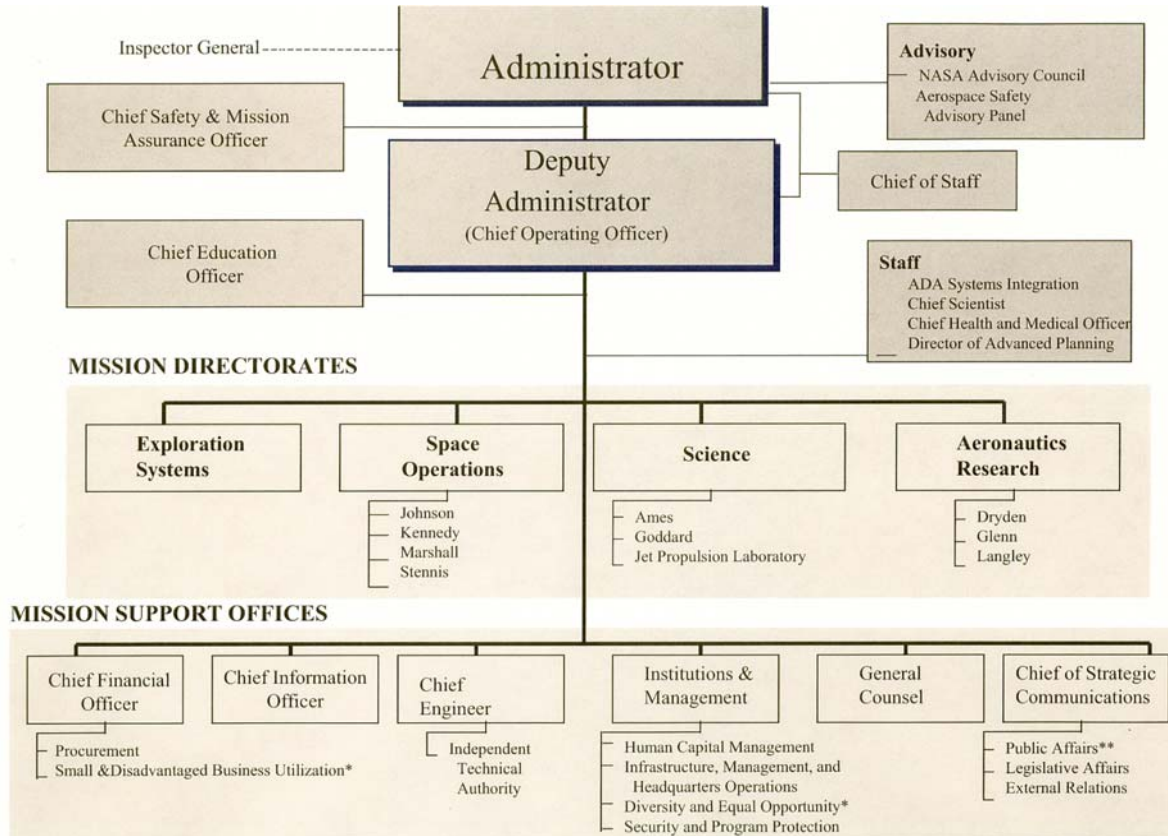
Six of the Enterprises were restructured into the four Mission Directorates: Aeronautics, Exploration, Science, and Space Operations. The Aeronautics Mission Directorate is the former Office of Aeronautics. The Exploration Mission Directorate is the Office of Exploration Systems combined with the Office of Biological and Physical Research. The Science Mission Directorate is a merger of the Office of Space Science and the Office of Earth Science. The Space Operations Mission Directorate is the former Office of Space Flight, which includes the space shuttle and the International Space Station programs.

The seventh Enterprise, Education, did not become a Mission Directorate. Instead, a new position of Chief Education Officer, reporting to the Deputy Administrator, was created.

The new organization chart is shown in **Figure 1**, but it must be stressed that the FY2005 NASA budget request, and therefore this report, use the organizational structure in existence at the beginning of 2004, not the August revision.

¹ NASA Press Release 04-205. Administrator Unveils Next Steps of NASA Transformation. [http://www.nasa.gov/home/hqnews/2004/jun/HQ_04205_Transformation.html]

Figure 1. NASA's New Organization Chart

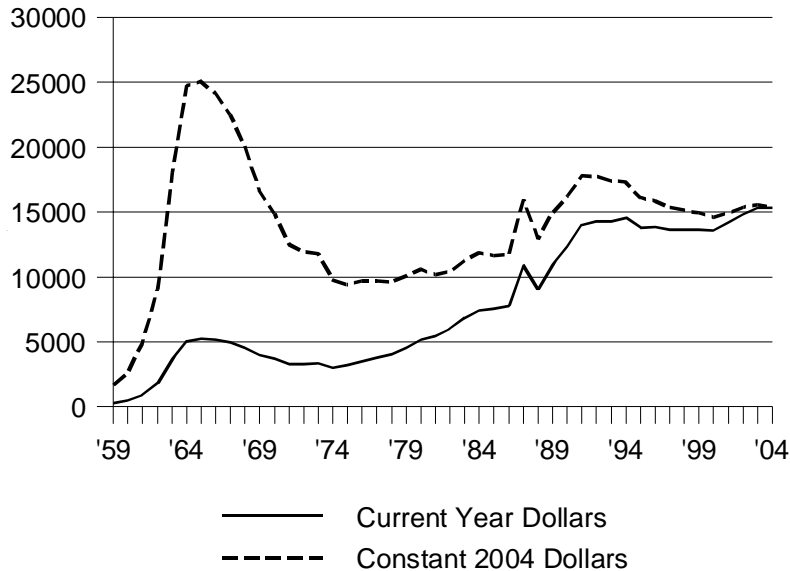


* In accordance with law, the Offices of Diversity and Equal Opportunity and Small and Disadvantaged Business Utilization maintain reporting relationships to the Deputy and the Administrator.
 ** Including a new emphasis on internal communications.

NASA's Historical Budget

Since its creation in 1958, NASA has experienced periods of budget growth and decline, some of which were dramatic. **Figure 1** displays the agency's budget history, both in current year dollars (i.e. unadjusted for inflation) and in constant 2004 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 year dollars) in FY1965. Then, as other national priorities gained precedence, NASA's budget declined sharply from the FY1965 peak to about \$3 billion (current year 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 thereafter.

Figure 2. NASA Budget Authority FY1959-2004 in Current and Constant Dollars (\$ millions)



Source: Current dollars for 1959-2000 are from the Aeronautics and Space Report of the President: FY2000; for 2001-2004 are from the Historical Tables of the Budget of the U.S. Government, FY2005. Constant dollars (adjusted for inflation to reflect 2004 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 (1995-2004)
(in millions of dollars)

Fiscal year	Current dollars (unadjusted for inflation)	2004 dollars
1995	13,854	16,117
1996	13,884	15,848
1997	13,709	15,380
1998	13,648	15,128
1999	13,653	14,937
2000	13,602	14,587
2001	14,257	14,940
2002	14,893	15,335
2003	15,391	15,593
2004	15,379	15,379

Source: Current dollars for 1995-2000 are from the Aeronautics and Space Report of the President: FY2000; for 2001-2004 are from the Historical Tables of the Budget of the U.S. Government, FY2005. The figure for 2004 is an estimate. Constant dollars (adjusted for inflation to reflect 2004 dollars) were calculated by CRS using the GDP (chained) price index.

Overview of NASA's FY2005 Budget Request

NASA's FY2005 budget request was \$16.2 billion, a 5.6% increase over the agency's FY2004 appropriations.² Congress appropriated \$16.200 billion in the FY2005 Consolidated Appropriations Act (H.R. 4818, P.L. 108-447), or \$16.070 billion when adjusted for an across-the-board 0.80% rescission.³ Congress also appropriated \$126 million in the FY2005 Military Construction Appropriations and Emergency Hurricane Supplemental Appropriations Act (P.L. 108-324).

NASA has three budget accounts. In the FY2005 request, they were entitled: Exploration, Science, and Aeronautics; Exploration Capabilities; and Inspector General. The seven Enterprises discussed earlier were assigned to one of the two major accounts. In the order of their appearance in the budget request, Space Science, Earth Science, Biological and Physical Research, Aeronautics, and Education Enterprises comprise the Exploration, Science, and Aeronautics account. The Exploration Systems and Space Flight Enterprises comprise the Exploration Capabilities account.

² NASA's FY2004 appropriations are included in the FY2004 Consolidated Appropriations Act (P.L. 108-199).

³ H.R. 4818 included a 0.83% rescission in Division J, Sec. 122. However, H.Con.Res. 528 changed that figure to 0.80%.

NASA has been changing its *budget* structure over the past several years, as well as its organizational structure (discussed earlier). Some of the changes reflect the organizational modifications, but others are the result of NASA's decision to shift to full cost accounting, which is explained in last year's version of this report (CRS Report RL31821). Briefly, it means that all program costs — including civil service salaries and facilities, e.g. — are counted in a program's budget, instead of separately, as was done in the past. The shift to full cost accounting began in FY2002, making budget comparisons with prior years virtually impossible at the program level. Generally, budgets can be compared on a year-to-year basis at the program office level (Space Science, Earth Science, etc.), but there are exceptions because projects sometimes are moved from one program office to another. For example, Project Prometheus, to develop space nuclear power and propulsion, originally was in the Office of Space Science because its first application was for a robotic probe to Jovian moons. In FY2005, however, it was shifted to the Office Exploration Systems because it may have wider application to other NASA activities.

Table 2. NASA's FY2005 Request and Appropriations
(in \$ millions)

Category	FY2004 approp.	FY2005 Req.	FY2005 Appropriations*			
			House Cmte.	Senate Cmte.	Conf.	Conf. adj. for rescission
Exploration, Science, & Aeronautics**	7,830	7,760	7,621	7,937	7,743*	not available
— Space Science	3,971	4,138				
— Earth Science	1,613	1,485				
— Biol. & Phys. Res.	985	1,049				
— Aeronautics	1,034	919				
— Education	226	169				
Exploration capabilities	7,521	8,456	7,497	8,411	8,426*	not available
Exploration systems	1,646	1,782				
— <i>Space Launch Init.</i>	†	†				
— <i>Other</i>	†	†				
— <i>Human & Robotic Tech.</i>	679	1,094				
— <i>Transportation Systems</i>	967	689				
Space Flight	5,875	6,674				
— <i>Space Station</i> ††	1,498	1,863				
— <i>Space Shuttle</i>	3,945	4,319				
— <i>Space Flight Support</i>	432	492				
Inspector General	27	28	31	32	32	32

Category	FY2004 approp.	FY2005 Req.	FY2005 Appropriations*			
			House Cmte.	Senate Cmte.	Conf.	Conf. adj. for rescission
Total	15,378	16,244	15,149	16,379	16,200*	16,070*

Source: NASA FY2004 and FY2005 budget justifications, and FY2005 VA-HUD-IA appropriations bills (H.R. 5041/S. 2825, H.R. 4818) with associated reports.

Note: Totals may not add due to rounding.

* The House and Senate Appropriations Committee reports, and the conference report on H.R. 4818 (the FY2005 Consolidated Appropriations Act, H.Rept. 108-792) do not include the level of detail needed to definitively determine totals for the subcategories in this table. Also, Congress gave NASA “unrestrained transfer authority” to shift funding between its two major accounts. Thus, the figures shown as the “Conf.” numbers for those two accounts may change as they are adjusted for the rescission or NASA makes other changes. The totals shown for NASA do not include \$126 million for hurricane relief provided in an emergency supplemental appropriations act (P.L. 108-324). The supplemental funding was not subject to the rescission.

** NASA requested that this account be renamed “Exploration, Science, and Aeronautics” to emphasize the Vision for Space Exploration, so that is the name used in this table. However, Congress declined to rename it, retaining last year’s name: “Science, Aeronautics, and Exploration.”

† NASA’s FY2005 request assumes cancellation of the Space Launch Initiative, reallocation of its remaining funding, and restructuring of “Crosscutting Technologies,” of which SLI was a part.

†† Not including funds for research aboard the space station, which is in the Biological and Physical Research line. For FY2004, that is \$578 million; for FY2005, it is \$549 million.

Summary of Congressional Action

The following is a summary of actions taken on the FY2005 budget request. As noted in the Preface, the amounts discussed in the remainder of this report are as provided in the conference version on H. R 4818, and are not adjusted for the 0.80% across-the-board rescission. Many of the programs mentioned in this summary are discussed in more detail later in the report. Separately, NASA received \$126 million in an emergency supplemental that was attached to the FY2005 Military Construction Appropriations Act (P.L. 108-324) for hurricane relief.

In brief, NASA requested \$16.244 billion and Congress appropriated \$16.200 billion. Those figures by themselves may not sufficiently convey the controversy that surrounded NASA’s budget, and may be somewhat misleading because more than \$1 billion of the funding must go for activities that were not included in the budget request. First, as noted, the \$16.200 billion is subject to the 0.80% across-the-board rescission, making the actual total \$130 million less (\$16.070 billion). Second, during the time Congress was considering the FY2005 request, NASA concluded that it needed an additional \$762 million in FY2005 to return the shuttle to flight status.

Also, Congress directed NASA to spend \$291 million on a Hubble servicing mission, and added at least \$200 million in other congressionally-directed spending.

Consequently, the amount of money available to cover the content of the FY2005 request is approximately \$14.8 billion (\$16.07 billion minus those amounts). Therefore, even though it might appear that NASA got what it requested for FY2005, difficult choices will have to be made about what programs to fund. As discussed

below, Congress gave NASA “unprecedented” authority to transfer money between its two major accounts, allowing the agency to make those choices.

FY2005 Appropriations. The House Appropriations Committee version of the FY2005 VA-HUD-IA bill (H.R. 5041, H.Rept. 108-674) cut \$1.1 billion from the request. Much of the reduced funding was from new initiatives associated with the Vision. The committee stated that it supports the Vision, but “does not have sufficient resources to meet the full budget request for NASA in FY2005. However, the Committee is hopeful that if additional resources are identified as the legislative process moves forward, it may be possible to augment NASA funding.” The committee declined to rename the “Science, Aeronautics, and Exploration” budget account as the “Exploration, Science, and Aeronautics” account as requested, stating that it “is supportive of the exploration aspects of NASA’s vision, [but] does not believe it warrants top billing over science and aeronautics.” The committee fully funded the space shuttle program, and the Mars Exploration program (which includes the two robotic rovers, Spirit and Opportunity, now exploring the Martian surface).

The Senate Appropriations Committee (S. 2825, S.Rept. 108-353) recommended \$16.4 billion, \$135 million over the request. That includes \$800 million designated as emergency spending: \$500 million for the space shuttle (in addition to fully funding the \$4.3 billion request), and \$300 million for a mission to repair the Hubble Space Telescope. (The funding for Hubble was split as follows: \$100 million in the Exploration Capabilities account, and \$200 million in Exploration, Science, and Aeronautics account.) The \$800 million in emergency spending was added during full committee markup of the bill on September 21, 2004. The VA-HUD-IA subcommittee had recommended \$15.58 billion for NASA, a reduction of \$665 million from the request.⁴

Neither chamber brought the VA-HUD-IA appropriations bill to the floor for a vote. Instead, a compromise version (essentially a conference report) was incorporated into H.R. 4818, the FY2005 Consolidated Appropriations Act (P.L. 108-447). That act gave NASA “unrestrained transfer authority” except for programs specifically identified in the conference report (H.Rept. 108-792). Thus, it is not possible at this time to definitively state how much funding most individual NASA programs received.

According to media reports, conferees had agreed to fund NASA at a level of \$15.9 billion in H.R. 4818, but House Majority Leader DeLay insisted that NASA

⁴ The Senate VA-HUD-IA subcommittee did not hold a formal markup on the bill. Instead, the bill was “polled out.” The report (S.Rept. 108-353) was drafted following subcommittee markup and many of the figures in the NASA section do not reflect the \$800 million added during full committee markup. The \$800 million addition is reflected in the bill language, where it can be discerned that the \$300 million for Hubble was split as indicated here (which is not clear from the report language). Also, some of the figures in the report appear to be incorrect. For example, it says on p. 3 that the committee provided \$15,579,200,000 for NASA, the same as the FY2004 level. In fact, the committee provided \$16,379,200,000, and the FY2004 level was \$15.378 billion. Thus, the report should be used cautiously.

receive \$16.2 billion or he would not bring the bill to the floor for a vote.⁵ Mr. DeLay's congressional district will soon include NASA's Johnson Space Center.

Tables 3 and 4 summarize the major reductions and additions made by the House and Senate Appropriations committees that were specifically identified in the committee reports, and by conferees on H.R. 4818, the FY2005 Consolidated Appropriations Act (P.L. 108-447). These tables represent a best effort to identify those cuts and additions, but should not be considered definitive. Report language is not always clear, for example, as to whether money is being added for an activity, or NASA is being directed NASA on how to spend money within the requested amount. Also, the sums of the specified additions and reductions in the House and Senate Committee reports do not result in the totals shown for the budget accounts, so other non-specified reductions (and, perhaps, additions) apparently have been made by the committees.

Table 3. Comparison of Appropriations Reductions

House Committee	Senate Committee	Final (H.R. 4818)
Space Science		
all \$70 million from Lunar Exploration probes	\$50 million of the \$70 million for Lunar Exploration probes	\$60 million of the \$70 million for Lunar Exploration probes
\$12.4 million of the \$12.5 million requested for scientific instruments for the Jupiter Icy Moons Orbiter (JIMO) [the remainder of the funding for JIMO is part of Project Prometheus, which also was cut — see Exploration Systems, below]*	The committee may have cut funds from the JIMO scientific instruments when it cut funding for Project Prometheus (see Exploration Systems, below)*	Not specified (see text)
\$15 million from "other" technology and advanced concepts (there are several such line items; the report does not specify from which of these accounts the cut is made)	\$50 million from \$126 million for Mars Program Plans & Architecture	Not specified (see text)
\$5 million of the \$378 million from other research in Structure and Evolution of the Universe		Not specified (see text)
\$5 million of the \$47 million for Living with a Star	(see Table 4)	(see Table 4)

⁵ Gugliotta, Guy. DeLay's Push Helps Deliver NASA Funds. Washington Post, December 6, 2004, A1.

House Committee	Senate Committee	Final (H.R. 4818)
Earth Science		
\$20 million of the \$54 million for the CCRI Glory mission		Not specified (see text)
\$15 million of the \$45 million for the Orbiting Carbon Observatory		Not specified (see text)
Biological and Physical Research		
\$103 million of the \$309 million for bioastronautics research	\$123.5 million from \$491.5 million for Biological Sciences Research (which includes bioastronautics research)	Not specified (see text)
Exploration Systems		
all \$438 million from the (CEV)**	\$160 million from the CEV**	Not specified (see text)
\$30 million of the \$115 million for technology maturation	all \$115 million from technology maturation	Not specified (see text)
\$230 million of the \$438 million for Project Prometheus, stating that the money is cut from the part of the Project that is related to JIMO (see Space Science above)*	\$8 million of the \$438 million for Project Prometheus (the committee also may have cut funds for the JIMO scientific instruments in the Space Science subaccount)*	Not specified (see text)
\$100 million from the \$261 million requested for terminating the Space Launch Initiative (to accelerate termination)	\$10 million of the \$20 million for Centennial Challenges	\$10 million of the \$20 million for Centennial Challenges
Space Flight		
\$190 million from the \$1.9 billion for the space station — \$120 million from the line that funds construction and operations, plus \$70 million of the \$140 million for ISS Crew/Cargo Services	\$260 million from the \$1.9 billion for the space station — \$120 million from the line that funds construction and operations, plus all \$140 million from ISS Crew/Cargo Services	Not specified (see text)
Other		
		Across-the-board 0.80 % rescission

Source: Prepared by CRS based on the House and Senate Appropriations Committee reports on the FY2005 VA-HUD-IA appropriations bills (H.R. 5041, H.Rept. 108-674; S. 2825, S.Rept. 108-353), and the FY2005 Consolidated Appropriations Act (H.R. 4818, H.Rept. 108-792). See text for cautionary notes about use of this table.

* In FY2004, Project Prometheus was in the Space Science subaccount, and included the development of nuclear power and propulsion systems, and a spacecraft with scientific instruments to use those new systems to study three Jovian moons — the Jupiter Icy Moons Orbiter (JIMO)

mission. In the FY2005 request, Project Prometheus, minus the scientific instruments, was transferred to the Exploration Systems subaccount, with a request of \$438 million. JIMO’s scientific instruments remained in the Space Science subaccount, with a request of \$12.5 million. The Senate report states that it funds “the entire Prometheus program at \$430 million. Although portions of Prometheus are found within other accounts at NASA, the Committee has chosen to reflect a total funding level for this program.” (p. 122) This suggests that the funding reduction will apply to the JIMO scientific instruments, but it is not mentioned in the committee’s discussion of the Space Science subaccount.

** The House report states that \$438 million is reduced by delaying CEV (p. 134), although the NASA request for that program is \$428 million (p. EC 3-3). The Senate report says that it is funding CEV at \$268 million (p. 122), which would be a cut of \$160 million from the \$438 million level.

Table 4. Comparison of Appropriations Additions

House	Senate	Final (H.R. 4818)
Space Science		
	\$300 million for a repair mission to the Hubble Space Telescope, designated as emergency spending.	\$291 million for a repair mission to Hubble.
	\$25 million added to the \$47 million for Living with a Star.	\$35 million added to the \$47 million for Living with a Star.*
Earth Science		
	\$15 million added to the \$77 million for Earth Science Applications.	\$15 million added to the \$77 million for Earth Science Applications.
Aeronautics Research		
	\$25 million for hypersonics research (not clear as to which subaccount this is added to, but the total request for Aeronautics Research is \$919 million; also, this may be a direction on how to spend requested money rather than an addition).	\$25 million for hypersonics research following on the successful X-43A test (this may be a direction on how to spend requested money rather than an addition).
Education		
\$9 million added to the \$21 million requested for the National Space Grant and Fellowship Program		\$9 million added to the \$21 million requested for the National Space Grant and Fellowship Program
\$7.4 million added to the \$4.6 million requested for the Experimental Program To Stimulate Competitive Research (EPSCoR)		\$7.4 million added to the \$4.6 million requested for the Experimental Program To Stimulate Competitive Research (EPSCoR)
Exploration Systems		
\$30 million added to the		\$30 million added to the \$161

House	Senate	Final (H.R. 4818)
\$161 million for the Innovative Technology Transfer Partnerships (ITTP) Program “for the express purpose of continuing the commercial programs, including the activities of associated NASA personnel, as they existed in FY2003 and prior fiscal years.”		million for the Innovative Technology Transfer Partnerships (ITTP).
Space Flight		
	\$500 million for space shuttle return to flight activities (designated as emergency spending).	No money added, but report language states that NASA may request a supplemental, or transfer funds from other activities.
Inspector General		
\$3.8 million added to the \$27.6 million requested	\$4 million added to the \$27.6 million requested	\$4 million added to the \$27.6 million requested
Other Congressionally Directed Spending**		
		\$217-450 million**

Source: Prepared by CRS based on the House and Senate Appropriations Committee reports on the FY2005 VA-HUD-IA appropriations bills (H.R. 5041, H.Rept. 108-674; S. 2825, S.Rept. 108-353), and the FY2005 Consolidated Appropriations Act (H.R. 4818, H.Rept. 108-792).

Note: See text for cautionary notes about use of this table. Funding figures do not reflect the 0.80% across-the-board reduction.

*The conferees specifically added \$35 million for FY2005. The report also says that the conferees approve \$681 million for the Living with a Star program, but it is not clear what time period that covers.

**Congress often adds funds to appropriations bills, including NASA’s. In some cases, it is for an ongoing program, such as the \$35 million added for Living with a Star, or other projects identified in this table. In other cases, the funding is for a specific project in a home state or district, with a specific performer identified, such as a university. In still other cases, congressional report language may be unclear about who the performer is, giving only the name of an activity, such as “Hydrogen Research Initiative.” That could be a reference to the DOE-led program to develop hydrogen-fueled cars, or to the Hydrogen Research Initiative at Florida State University which has received funds from NASA in the past. The term “earmark” is often used to characterize these additions, but there are various definitions of “earmark.” Some define it broadly to mean any funding added by Congress. Others define it more narrowly to mean funding added by Congress for a specific project conducted by a specific non-government performer. Another complication is that report language may say only that money is “provided” for an activity, not clarifying whether that is an addition, or a direction to NASA to spend appropriated funds in a certain manner. Consequently, different organizations that calculate “earmarks” may report significantly different figures. The American Association for the Advancement of Science (AAAS) calculates that the FY2005 NASA budget has \$217 million in “congressionally-designated, performer-specific” earmarks [<http://www.aaas.org/spp/rd/upd1104.htm>]. *Space News* (November 29, 2004, p. 11) reports “earmarks...with a combined value of more than \$400 million.” *Aerospace Daily* (December 2, 2004, p. 1) uses “about \$450 million in earmarks.”

FY2005 Authorization. The Senate Commerce, Science, and Transportation Committee reported a five-year (FY2005-2009) NASA authorization bill (S. 2541, S.Rept. 108-418) that essentially recommends the amounts requested by NASA. One difference is that the bill would create a separate budget account, with \$15 million in FY2005, for an Independent Technical Engineering Authority that is not tied to any specific NASA program and would be responsible for technical standards for the space shuttle and waivers thereto. The *Columbia* Accident Investigation Board, which investigated the 2003 space shuttle *Columbia* accident, recommended that NASA establish an Independent Technical Authority (ITA) that would have similar functions. NASA is setting up the ITA; it reports to the NASA Chief Engineer.

A companion FY2005 authorization bill was not introduced in the House. Because there was no final action on an authorization bill, it is not discussed further in this report. NASA has been operating without an authorization act since the end of FY2002. The most recent enacted NASA authorization was for FY2000-2002 (P.L. 106-301).

NASA's Budget Debate in Context

Impact of The Space Shuttle Columbia Tragedy

On February 1, 2003, the space shuttle *Columbia* broke apart as it returned to Earth from a 16-day scientific research mission in Earth orbit. All seven astronauts — six Americans and one Israeli — perished.⁶ The tragedy has had a profound effect on NASA and the U.S. civilian space program. The human loss, and the immediate impact on the space shuttle and space station programs from the grounding of the shuttle fleet, are readily apparent. But *Columbia* also has had far-reaching repercussions for U.S. space policy by focusing the attention of the White House and Congress on the purpose of the U.S. human space flight program, and what should be its future, and the future of NASA overall.

In chapter nine of its report, the *Columbia* Accident Investigation Board (CAIB), which investigated the tragedy, looked toward the future. The CAIB noted that one of the realities that became evident during its deliberations was “the lack, over the past three decades, of any national mandate providing NASA a compelling mission requiring human presence in space.”⁷ In congressional testimony, CAIB chairman Adm. Harold Gehman (Ret.) stressed the need for a vision that is agreed upon by the White House, Congress, and the public.

⁶ For more about the *Columbia* tragedy, see CRS Report RS21408, *NASA's Space Shuttle Columbia: Quick Facts and Issues for Congress*, by Marcia S. Smith.

⁷ *Columbia* Accident Investigation Board. *Report*, volume 1. Washington, U.S. Govt. Print. Off., August 2003. p. 209. Also available at [<http://www.caib.us/>].

... it isn't NASA that needs a vision. It is the country that needs a vision. NASA has got lots of visions, but visions without resources are just dreams. We need an agreed vision, and then NASA can execute that.⁸

On January 14, 2004, President Bush announced a new vision for NASA. The President's "Vision for Space Exploration" is likely to form the basis for congressional and public debate about NASA and its budget for many years to come.

Prior to *Columbia*, the White House displayed little interest in the space program other than improving financial management at NASA, particularly with regard to the International Space Station (ISS) program. Space program supporters pointed out that, as Governor of Texas, President Bush never visited Johnson Space Center (JSC) in Houston,⁹ which is home to NASA's astronaut corps and a major NASA center involved in the human spaceflight program. His appointment of a NASA administrator, Sean O'Keefe, with a background in public administration rather than aerospace, was viewed by space program supporters as a signal that NASA was not a high priority for the Bush Administration. Mr. O'Keefe had been deputy director of the Office of Management and Budget (OMB), where he was best known to the space community as the architect of the plan to truncate construction of the ISS in light of substantial cost growth announced days after President Bush took office (see CRS Issue Brief IB93017, *Space Stations*, by Marcia Smith).

At NASA, Mr. O'Keefe's early actions seemed designed to emphasize that robotic space exploration rather than human space flight was his priority. He created a new vision statement and mission statement for the agency, and declared that NASA's mission was "science-driven," apparently indicating that new programs would be chosen based primarily on their scientific value. Whereas human space flight traditionally had top billing in NASA budget documents, he renamed NASA's budget accounts and reversed the order of their appearance apparently to emphasize that scientific missions were the *raison d'être* for the agency, and "Space Flight Capabilities" such as ISS and the shuttle existed to support those goals. Between his hard-line position on ISS cost growth, and symbolically demoting ISS and the shuttle to a place behind science, aeronautics, and robotic space exploration, many human space flight supporters worried about the future. Meanwhile, President Bush was silent about the space program.

The situation changed after the *Columbia* tragedy, however. President Bush's first public statement about the space program was informing the nation of the loss of *Columbia* and her crew. Three days later he visited JSC to pay tribute to the crew. On that first (and, to date, only) journey there, his speech raised hopes for supporters

⁸ U.S. Congress. House. Committee on Science. The *Columbia* Accident Investigation Board Report. Hearing. September 4, 2003. 108th Congress, 1st sess. Washington, U.S. Govt. Print. Off., 2004. p. 57.

⁹ For example, see statement by Representative Nick Lampson at a hearing of the House Science Committee on NASA's FY2003 budget request on February 27, 2002, extending an invitation to the President to visit JSC because he had not had an opportunity to do so while governor. Hearing transcript provided by Federal Document Clearing House (via Factiva). Also see Fleischer: "Bush Didn't Visit NASA as Gov." *Associated Press Online*, February 4, 2003 (via Factiva).

of the human space flight program, saying — “The cause of exploration and discovery is not an option we choose; it is a desire written in the human heart.”¹⁰ A year later, on January 14, 2004, speaking from the auditorium at NASA Headquarters, he made a major space policy address in which he directed NASA to focus its activities on returning humans to the Moon by 2020, and someday sending them to Mars and “worlds beyond.” This “Vision for Space Exploration” is discussed below. In contrast to his April 2002 announcement that NASA would be “science-driven,” Mr. O’Keefe made clear in a press conference immediately after the President’s announcement that NASA now would be driven by exploration goals. “It will be informed by the science, to be sure. And there are science objectives you’ll see.... But they’re specifically driven by exploration goals.”¹¹

The President’s directive, set in motion by *Columbia*, dramatically altered NASA’s plans. Whether or not it proceeds as outlined by the President, its announcement already is changing the agency by challenging long-standing expectations. For example, many had assumed that the space shuttle would operate at least until a replacement for it was available. The President’s plan calls for terminating the shuttle in 2010, and terminating the program that was developing technologies for a successor (the Space Launch Initiative). Instead, a “Crew Exploration Vehicle” will be built to take astronauts to the Moon, but its Earth-orbital version would not be available until 2014, meaning that the United States will give up its own capabilities to place astronauts in space for four years. NASA will have to rely on Russia for transporting astronauts to ISS (if such an agreement can be negotiated). NASA’s use of ISS itself would change — from a broadly-based scientific research program to one focused only on what is needed to accomplish the Vision. Importantly, NASA would end its use of ISS six or seven years after construction is completed, instead of 10 years or more as planned. It is not clear that Congress will approve those decisions,¹² but the proposal alone is a substantial paradigm shift. If the Vision is implemented as outlined by the President, the *Columbia* accident will be remembered as leading to the termination of the shuttle program. But it would also have served as the catalyst for the United States to embark upon a bold new direction in human space exploration.

If the Vision is not embraced by Congress and the public, it is not clear in what direction NASA will travel. A return to the pre-*Columbia* expectations of the space shuttle and space station operating to 2020 or beyond seems unlikely. NASA identified \$11.6 billion in FY2005-FY2009 that could be “redirected” to fund the

¹⁰ The White House. Office of the Press Secretary. “President Bush Attends Memorial Service for *Columbia* Astronauts. Remarks by the President at the Memorial Service in Honor of the STS-107 Crew.” February 4, 2003. [<http://www.whitehouse.gov/news/releases/2003/02/20030204-1.html>].

¹¹ Transcript of January 14, 2004 press conference provided by Federal Document Clearing House (via Factiva).

¹² As discussed later in this report, although Congress funded NASA at a level very close to its request for FY2005, which would indicate support for the Vision, conferees explicitly noted that Congress has not yet endorsed the initiative, and called on the appropriate authorizing committee to provide guidance. Thus, the extent to which Congress embraces the Vision remains unclear.

Vision (see **Table 5**). If Congress and the public are not persuaded to embark upon the Vision, or not to proceed at the pace called for in the President's speech, is it reasonable to assume that the proposed \$11.6 billion in cuts can be made in any case? How long should U.S. participation in the ISS program continue if the Vision is delayed or rejected? Under the President's plan, the only apparent reasons for U.S. involvement in ISS are fulfilling its commitments to the other partners in ISS (Canada, Europe, Japan, and Russia) and performing research associated with the Vision. If the latter rationale is eliminated, are the international commitments sufficient to warrant spending \$6.7 billion (\$2.4 billion for the space station and \$4.3 billion for the shuttle) in FY2005 alone? Are they worth the risk to astronaut lives inherent in human space flight? Or are there other reasons that U.S. taxpayers may wish to continue the human space flight program, such as its oft-cited value in demonstrating U.S. technological leadership, stimulating children to study math and science, or satisfying the intangible "desire written in the human heart" noted by President Bush in his tribute to the *Columbia* crew?

In short, if the Vision is adopted by Congress and the public, NASA will shift from a "science-driven" agency to an "exploration-driven" agency, with the focus on human exploration beyond low Earth orbit. If it is not adopted, many believe the shuttle program and U.S. use of the ISS may be terminated earlier than had been expected anyway, with no clear direction for the future. Whatever the outcome, events spurred by the *Columbia* accident represent a major turning point for NASA and the U.S. space program.

The Potential Impact of SpaceShipOne

On quite a different note, another factor that could shape NASA's future is a growing role for commercial space activities. The topic of commercial space activities generally is outside the scope of this report, but the success of SpaceShipOne, the first privately-developed spacecraft capable of taking people to space, could have important impacts on NASA's future direction.

Built by aircraft designer Burt Rutan and his company, Scaled Composites, SpaceShipOne is a small spacecraft that is delivered to an altitude of approximately 50,000 feet by an airplane called White Knight. The spacecraft then separates from the airplane and fires a rocket engine to reach an altitude of at least 100 kilometers (62.5 miles). That altitude is designated by an international aeronautical record keeping organization, the Federation Aeronautique Internationale (FAI), as the boundary between air and space (there is no legal definition of that boundary). SpaceShipOne does not go into orbit. The flights are suborbital, and once exceeding the 62.5 mile mark, the spacecraft returns to Earth and lands on a runway.

On a June 21, 2004 test flight of SpaceShipOne, pilot Mike Melvill became the first person to reach space on a vehicle built entirely with private funds.¹³ Paul Allen,

¹³ Mr. Melville is often referred to in the media as the "first commercial astronaut," but there have been several individuals who have flown into space as representatives of their companies, rather than space agencies. What is different about Mr. Melville is that he is the
(continued...)

co-founder of Microsoft, funded the spacecraft's development. Part of the impetus for creating SpaceShipOne was to win the \$10 million Ansari X-Prize [<http://www.xprize.com>]. Mr. Allen was widely reported to have spent about \$20 million on the project. To win, the company had to launch a spacecraft capable of carrying three people (at least one person actually had to be aboard) to space, return to Earth, and launch the same spacecraft again within two weeks. The two flights needed to win the X-prize were flown on September 29 and October 4, 2004. Mr. Melville piloted the first; Brian Binnie the second. Sir Richard Branson, founder of Virgin-Atlantic airline and head of the Virgin Group, is licensing the SpaceShipOne technology. He founded a company, Virgin Galactic, to offer commercial suborbital flights, and someday orbital flights, on a new generation of spaceships. He reportedly expects to invest about \$100 million in the new spaceships and associated ground infrastructure, and charge \$190,000 per person per flight.¹⁴

Thus, SpaceShipOne is seen by many as the first step in ushering in an era of affordable "space tourism." The first space tourist was American Dennis Tito, who flew to ISS on a Russian Soyuz spacecraft for a one-week visit in 2001. He was followed by South African Mark Shuttleworth in 2002. According to press reports, they each paid approximately \$20 million. Mr. Branson and others believe that the comparative affordability of SpaceShipOne flights will make space tourism a more realistic possibility for many people, even though they are brief, suborbital flights. The 108th Congress passed legislation establishing a regulatory regime for space tourism (see CRS Issue Brief IB93062, *Space Launch Vehicles: Government Activities, Commercial Competition, and Satellite Exports*, by Marcia Smith).

Hotel magnate Robert Bigelow announced another contest, America's Space Prize, in which the first company to develop a spacecraft for orbital spaceflight will win \$50 million.¹⁵ Mr. Bigelow's company, Bigelow Aerospace, is trying to develop an inflatable space station that would be used for tourism. He wants a privately-developed spacecraft to serve as the transportation system to it.

It is too early to know whether these efforts at developing the space tourism industry, and invigorating private sector alternatives to NASA-built human spacecraft, will be successful, but if they are, they could have an impact on NASA's future. One change that already has taken place is NASA's proposed adoption of the use of prizes to stimulate new technologies to achieve the Vision. Called the Centennial Challenges program, NASA requested \$20 million for FY2005, and Congress appropriated \$10 million.¹⁶

¹³ (...continued)

first person to reach space aboard a spacecraft built without government funds.

¹⁴ "Virgin Group Sign Deal with Paul G. Allen's Mojave Aerospace." Press release, September 27, 2004. [http://www.scaled.com/projects/tierone/092704_scaled_paul_allen_virgin_galactic.htm].

¹⁵ Covault, Craig. "Bigelow's Gamble," *Aviation Week & Space Technology*, September 27, 2004, p. 54 ff.

¹⁶ The funding is subject to Congress passing legislation authorizing NASA to award prizes (continued...)

Major NASA Budget Issues

President Bush's "Vision for Space Exploration"

As already discussed, 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 it is called the "Vision for Space Exploration," or simply "the Vision." CRS Report RS21720, *Space Exploration: Issues Concerning the 'Vision for Space Exploration'*, by Marcia Smith, discusses the Vision and the questions it is raising in Congress. In this report, the focus is on the budgetary impact of the proposal.

Briefly, under the President's plan, NASA would terminate the shuttle program in 2010 when construction of ISS is completed; discontinue the Space Launch Initiative (SLI), a two-faceted program that was developing technologies for a vehicle to replace the shuttle, and developing an "Orbital Space Plane" to take crews to and from ISS; restructure the U.S. ISS-based scientific research program to support only life sciences research associated with achieving the exploration goals instead of the broadly-based program that was planned; end U.S. use of ISS by FY2017; build a new Crew Exploration Vehicle (CEV)¹⁷ able to take astronauts to Earth orbit by 2014 and ultimately to the Moon; build robotic probes as "trailblazers" for the astronauts; and launch other robotic missions to explore the solar system and the universe, including a new space telescope. The President invited other countries to join in the initiative.

Cost and Budget (Including the "Sand Chart"). One of the first questions raised by the Vision is whether or not the nation can afford it at a time when the federal budget is under considerable stress due to the war in Iraq and rising budget deficits.

Initially, the President and NASA did not provide cost estimates for achieving the goals, only budget estimates for FY2005-FY2009, and a budget chart (the "sand chart," see **Figure 2**) extending to FY2020. The sand chart shows a NASA budget that increases approximately 5% in FY2005-FY2007, less than 1% in FY2008-2009, and is roughly level with inflation beyond FY2009. NASA says the intent of the chart is to demonstrate there is no "balloon" in funding past FY2009. The total amount of funding represented in the chart appears to be \$150-170 billion.

In late February 2004, however, NASA released a cost estimate for landing a crew on the Moon in 2020 — \$64 billion (FY2003 dollars): \$24 billion (FY2004-

¹⁶ (...continued)

in excess of \$250,000, the limit under its current authority. H.R. 5385 (Boehlert), S. 2541 (McCain), and S. 2917 (Brownback), all contained provisions related to providing this authority, but none cleared the 108th Congress.

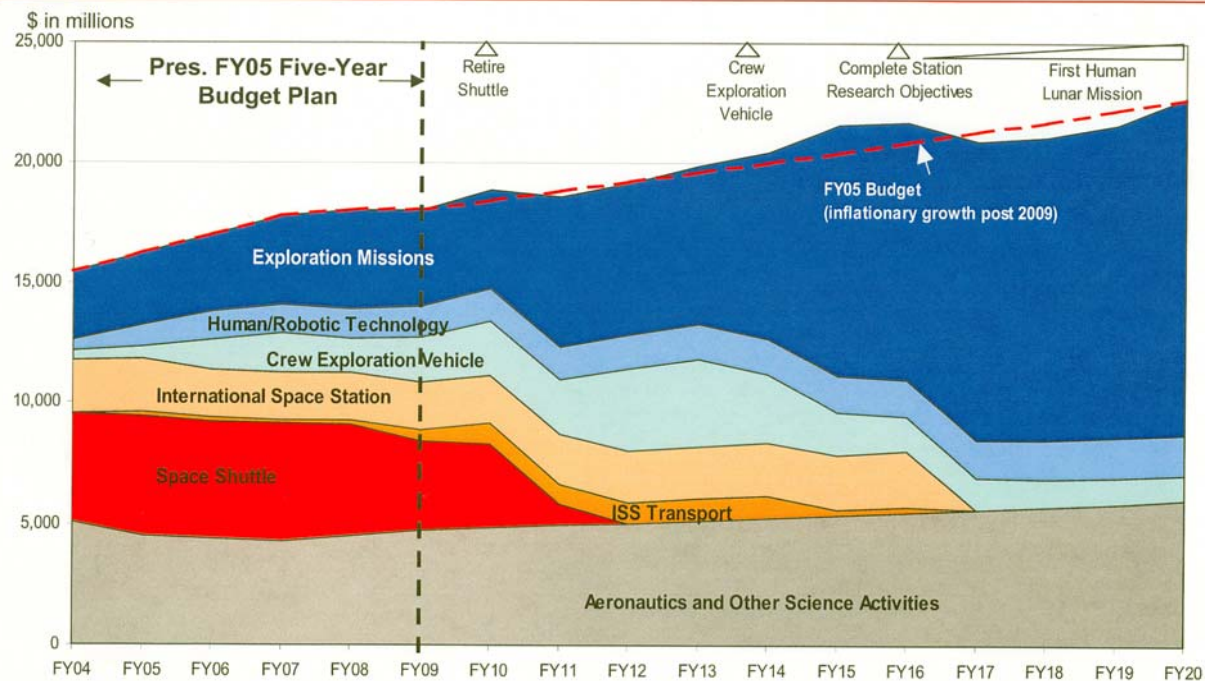
¹⁷ The term "Project Constellation" is variously used by NASA to refer to the CEV, or to the overall program to send humans back to the Moon and to Mars (the "Moon/Mars" program).

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. An estimate for sending astronauts to Mars was not provided by NASA.

Figure 3. NASA's "Sand Chart" of Projected Budget Authority

 **Strategy Based on Long-Term Affordability**

http://wikileaks.org/wiki/CRS-RL32676



NOTE: Exploration missions – Robotic and eventual human missions to Moon, Mars, and beyond
 Human/Robotic Technology – Technologies to enable development of exploration space systems
 Crew Exploration Vehicle – Transportation vehicle for human explorers
 ISS Transport – US and foreign launch systems to support Space Station needs especially after Shuttle retirement

As noted, the President does not plan to request an infusion of funds for NASA to accomplish the Vision. Although the White House and NASA said that \$12.6 billion would be “added” to NASA’s FY2005-2009 budget, only \$1 billion of that is new money. The remainder, \$11.6 billion, will be redirected from other NASA programs. Some question, therefore, whether the \$12.6 billion should be characterized as an “addition.” **Table 5** shows the proposed shifts in funding.

Table 5. NASA’s Proposed Reductions to Fund the Vision
(\$ in billions)

Activity	2005	2006	2007	2008	2009	Total
Discontinue SLI	-0.8	-1.2	-1.3	-1.2	-1.4	-5.9
Shuttle retirement	0.0	0.0	0.0	-0.2	-1.3	-1.5
Eliminate ISS research not tied to vision	-0.1	-0.2	-0.3	-0.3	-0.3	-1.2
<i>Human Space Flight related reductions</i>	-0.9	-1.4	-1.5	-1.7	-3.0	-8.6
Defer new space and earth science missions and freeze spending	-0.2	-0.5	-0.7	-0.7	-0.6	-2.7
Reduce space technology and defer institutional activities	-0.15	-0.03	-0.04	-0.05	-0.07	-0.3
<i>Other reductions</i>	-0.3	-0.5	-0.7	-0.8	-0.7	-3.0
Total reductions	-1.3	-1.9	-2.3	-2.5	-3.7	-11.6

Source: NASA briefing chart, February 5, 2004.

While congressional action on the FY2005 NASA budget was pending, and indications were that significant cuts would be made to the request for Vision-related projects, skeptics pointed out that President Bush had not spoken publicly about the Vision since his speech on January 14. Space supporters were surprised that it was not mentioned in the State of the Union address a week later, nor by the President in his reelection campaigning. Outside of NASA, the only public Bush Administration support for the Vision came from OMB Director Joshua Bolten and the White House Press Secretary Scott McClellan. Mr. Bolten wrote to the chairman of the House Appropriations Committee, Representative Young, on July 22, 2004 stating that he would recommend a veto of the FY2005 VA-HUD-IA appropriations bill if it included the committee-recommended cuts to NASA (and other programs unrelated to NASA). At a November 9, 2004 press conference, Mr. McClellan was asked if the Vision was on the “back burner.” He replied that it is a long-term vision that is in the budget plan, and the President remains committed to it.¹⁸ Mr. Bolten again wrote to appropriators on November 17, 2004 emphasizing the importance of adequate NASA funding (along with other issues) in the FY2005 consolidated

¹⁸ The White House. Office of the Press Secretary, Press Briefing by Scott McClellan. November 9, 2004. [<http://www.whitehouse.gov/news/releases/2004/11/20041109-8.html>].

appropriations bill, although he stressed that it should not be too little (as in the House version) or too much (as in the Senate version).¹⁹ The paucity of public statements in support of the Vision by the President, therefore, was not necessarily a signal of lack of White House support.

As discussed next, Congress ultimately appropriated a total for NASA that is quite close to its requested amount (\$16.200 billion compared with the \$16.244 billion request). House Majority Leader Delay is widely credited with winning that funding level for NASA.²⁰ While the total is close to the request, it does not reflect an across-the-board rescission of 0.80%, and some of the funding will be allocated to congressionally directed funding, rather than activities NASA requested. NASA also is facing challenges with the amount of money needed to return the space shuttle to flight (discussed elsewhere in this report). Conferees explicitly stated that Congress has not yet taken substantive action endorsing the project. They called on the appropriate House and Senate authorizing committees to provide guidance and authorization for the effort. Thus, the extent to which the FY2005 appropriations act can be viewed as a sign of congressional support for the Vision remains unclear.

Congress gave NASA significant latitude in how it spends its FY2005 funding. The conference report refers to it as “unrestrained transfer authority” between NASA’s two major accounts. NASA must notify Congress of how it plans to spend the money. Until it does, it is not possible to definitively determine how much funding will be allocated to Vision-related programs, other than the two specifically identified in the conference report (robotic lunar probes and the Centennial Challenges program).

FY2005 Budget Request. A NASA chart identifies \$4.5 billion of the agency’s FY2005 \$16.2 billion request as “exploration specific” — \$0.1 billion for lunar exploration, \$0.7 billion for Mars exploration, \$1.2 billion for “other solar system exploration,” \$1.1 billion for the Origins program, \$1.1 billion for Human & Robotic Technology, and \$0.4 billion for the CEV. That total does not include the space shuttle and ISS programs, which are among the first steps in achieving the Vision. Most of the \$4.5 billion would pay for existing activities now labeled as “exploration,” including the entire Mars exploration program (including the Spirit and Opportunity rovers now roaming the Martian surface), the Origins program (which includes the Hubble Space Telescope), and other space science and technology development projects. It is difficult to trace the individual elements of what constitutes the \$4.5 billion through the congressional funding process. The following list shows the major programs within the Office of Exploration Systems, which are the most easily-identifiable Vision-related projects.

- \$428 million for Project Prometheus, to develop nuclear power and propulsion systems that would first be used on a robotic spacecraft, the Jupiter Icy Moons Orbiter (JIMO), which would study three

¹⁹ The letter is available on OMB’s website [http://www.whitehouse.gov/omb/pubpress/fy2004/omni_ltr_111704.pdf].

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

Jovian moons (the \$428 million is split between development of the nuclear systems and the JIMO spacecraft);

- \$428 million for the Crew Exploration Vehicle (CEV) to take astronauts to the Moon;²¹
- \$261 million for termination costs associated with the Space Launch Initiative;
- \$115 million for technology maturation;
- \$360 million for advanced space technology; and
- \$20 million for the Centennial Challenges “prize” program.

In addition, \$70 million in the Office of Space Science (OSS) is for robotic lunar probes to obtain information to support a human return to the Moon. OSS sources make clear that they are managing the program for the Office of Exploration; it is not part of their own plans for scientific research associated with the Moon.

Congressional Action. Tables 3 and 4 provide more detail about reductions and additions made by in the appropriations process. The House and Senate Appropriations Committees expressed support for the President’s goals, but cited the constrained budgetary climate as a factor in their decisions to cut some of the Vision-related programs.

The House Appropriations Committee made the following cuts:

- \$230 million from Prometheus;
- \$438 million from CEV (the request was \$428 million, but the House report said \$438 million would be saved by delaying CEV);
- \$100 million from SLI (to accelerate termination); and
- \$30 million from technology maturation.

Related cuts in other parts of NASA, such as all \$70 million from the robotic lunar probes, are shown in **Table 3**.

The Senate Appropriations Committee made the following cuts:

- \$8 million from Prometheus;
- \$160 million from CEV (using \$438 million as the requested level, as cited in the House report);
- all \$115 million from technology maturation; and
- \$10 million from Centennial Challenges.

Related cuts in other parts of NASA, such as \$50 of the \$70 million for robotic lunar probes, are shown in **Table 3**.

Conferees largely left the issue of how to allocate the FY2005 budget to NASA itself. Of the Vision-related projects, the two for which a funding level is specified are robotic lunar probes and the Centennial Challenges program. The first in the

²¹ As noted earlier, the House Appropriations Committee report states that \$438 million will be saved by delaying the CEV, although the request in the NASA budget is for \$428 million.

robotic lunar probe series is the Lunar Reconnaissance Orbiter (LRO), for which NASA requested \$70 million. The conferees provided \$10 million instead, and directed that no less than 25% of the instruments be designed to answer basic science questions about the Moon, rather than on “applied engineering assessments” of potential human and robotic lunar landing sites in support of the Vision. They argued that since the LRO is funded from NASA’s space science budget, some of the instruments should support science goals. The conferees provided \$10 million of the \$20 million for Centennial Challenges (a program that will offer “prizes” for those who develop innovative technologies for the Vision), subject to the passage of authorizing legislation that would permit NASA to award prizes larger than \$250,000 (which they can do based on existing law).

The conferees also provided \$3 million for modeling and simulation related to systems development for the Vision. Conference report language is not clear as to whether that is an additional \$3 million, or if NASA is to use that amount of otherwise appropriated funds for that purpose.

Report language provided further information on the conferees’ concerns about the Vision. Their comments included the following.

- 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 the National Academy of Sciences to conduct a “thorough review” of the science that NASA plans to undertake as part of the Vision, and develop a strategy by which all of NASA’s science disciplines — Earth science, space science, life and microgravity science, and science conducted aboard ISS — can make adequate progress towards their goals, and provide balanced scientific research in addition to supporting the Vision. The review is due by March 15, 2005.
- They noted that although they were appropriating substantial funds for the Vision, “to date there has been no substantive Congressional action endorsing the initiative. The conferees note that the initiative is a very long-term endeavor and will require tens of billions of dollars over the next two decades. As such, the initiative deserves and requires the deliberative benefit of the Congress. To this end, the conferees call upon the appropriate Committees of jurisdiction of the House and Senate for action to specifically endorse the initiative and provide authorization and guidance.” 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. They 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, within 60 days of the bill's enactment. 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 their findings and recommendations.

Return to Flight of the Space Shuttle

As already discussed, the space shuttle *Columbia* broke apart as it returned to Earth on February 1, 2003, killing all seven astronauts aboard. The shuttle fleet remains grounded. The most recent time frame for its Return to Flight (RTF) is a launch window from May 12-June 3, 2005. CRS Report RS21408 provides more information about the *Columbia* tragedy. CRS Report RS21606 provides a synopsis of the findings and recommendations of the *Columbia* Accident Investigation Board (CAIB). The full CAIB report is available at [<http://www.caib.us>]. The CAIB made 29 recommendations, including 15 that must be accomplished before the shuttle returns to flight. NASA created an advisory group — the "Stafford Covey" task group — to oversee compliance with the CAIB recommendations. For more information on that group, see CRS Issue Brief IB93062, *Space Launch Vehicles: Government Activities, Commercial Competition, and Satellite Exports*, by Marcia Smith.

NASA initially hoped to resume shuttle launches in 2004, but that slipped into the early spring of 2005, and, most recently, to May/June 2005. If RTF occurs in May, it will have been about 28 months since the accident. In the two other cases of U.S. spaceflight-related fatalities (the 1967 Apollo 204 fire, which killed three astronauts; and the 1986 space shuttle *Challenger* tragedy, which killed seven astronauts), the programs were suspended for 21 months and 32 months, respectively.

The primary purpose of the shuttle system today is support of the ISS. 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 international partners in the ISS program — Canada, Europe, Japan, and Russia — have been keeping two-man crews aboard ISS using Russian spacecraft in the interim.

NASA and its contractors are working to resume shuttle launches as soon as possible, consistent with ensuring the shuttle is as safe as possible, in order to continue ISS construction and servicing. One issue is whether schedule pressure could influence shuttle program managers to take shortcuts, and if the Vision adds to that pressure. President Bush has called for ISS construction to be completed by 2010, at which point the shuttle system would be retired in order to free funds for the

Vision. NASA estimates that 28 shuttle launches are required to complete construction. NASA's FY2005 request includes "out-year" projections that reduce the shuttle budget by a total of \$1.5 billion in FY2008 and FY2009 to help pay for the Vision (see **Table 5**). The CAIB cited schedule pressure as one factor in the *Columbia* tragedy. It also noted that funding was taken from the shuttle budget over several years to pay for other NASA programs, particularly ISS. NASA's willingness to slip RTF repeatedly suggests to some that NASA is proceeding cautiously, but the agency's plan to launch 28 flights in less than six years makes others worry that an environment similar to that prior to *Columbia* is being recreated.

Although the budget projection for the Vision assumes reductions from the shuttle program in FY2008 and FY2009, in the near term, shuttle costs instead are increasing. NASA revises its implementation plan for RTF periodically, usually issuing a new estimate of RTF costs and emphasizing that the actual costs are not known. In July 2004, the total estimate for FY2003-FY2009 was \$2.2 billion, twice the previous estimate of \$1.1 billion. NASA reported in November 2004 that it will need \$762 million more in FY2005 expected for the shuttle program.²²

As discussed later in this report, there is much debate about the shuttle's future.

FY2005 Budget Request. 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 needs \$762 million more in FY2005 for the shuttle program, but a budget amendment was not submitted.

Congressional Action. Congress appropriated \$4.3 billion. The House and Senate Appropriations Committees both had recommended full funding, and the Senate committee also added \$500 million designated as emergency spending. The conference version, however, provided the requested level, and noted that the Administration could request supplemental funding, or transfer funds from other NASA programs, if necessary.

Hubble Space Telescope

The Hubble Space Telescope, launched in 1990, was designed to be serviced regularly by astronauts. Servicing missions via the space shuttle in 1993, 1997, 1999, and 2002 installed corrective optics, repaired and replaced aging components, and added new, more advanced scientific instruments. At the time of the *Columbia* tragedy, another servicing mission was planned for a 2004 shuttle flight, and a shuttle mission in 2010 was planned to retrieve the telescope and return it to Earth. These plans changed in January 2004, when Administrator O'Keefe, citing safety concerns, announced that the space shuttle will no longer be used for flights to Hubble, either

²² At the time of the FY2005 budget request, NASA anticipated RTF costs of \$238 million in FY2005, which it thought it could cover using "reserves" in the shuttle account. By November 2004, NASA estimated \$1 billion in RTF costs in FY2005. After applying the \$238 million in reserves, the balance needed is \$762 million.

for servicing or for retrieval.²³ NASA estimates that without a servicing mission, Hubble would cease scientific operations in about 2008 and, if left unattended, make an uncontrolled reentry in about 2012. NASA is now considering various options, including the possibility of robotic servicing and deorbiting. Throughout most of 2004, robotic options dominated the public discussion of Hubble's future. On December 8, 2004, however, a report by the National Academy of Sciences found it "unlikely that NASA will be able to extend the science life of [Hubble] through robotic servicing," recommended a servicing mission by astronauts in the space shuttle, and recommended a robotic mission only for deorbiting the telescope "after the period of extended science operations enabled by" shuttle servicing.²⁴

In past years, there have been concerns in the scientific community about the relationship between the end of Hubble operations and the beginning of operations of its planned successor, the James Webb Space Telescope (JWST). These issues mainly revolved around NASA's plans to fund JWST from the "wedge" created by a reduction in funding requirements for Hubble. A related concern was the possible impact on scientists if there is a gap in operations between Hubble and JWST. Although these issues remain, they have been overshadowed this year by the question of the future of Hubble itself.

FY2005 Budget Request. For FY2005, NASA requested \$130.1 million for Hubble, including \$29.7 million for development, \$6.9 million for operations, and \$93.5 million for data analysis. At the time the FY2005 budget was released (shortly after Mr. O'Keefe's announcement that the shuttle would not fly to Hubble), NASA intended to cancel the 2004 servicing mission entirely, and was only in the earliest stages of studying the possibility of robotic retrieval. For this reason, the potential costs of robotic servicing and retrieval were not included in the FY2005 request. Press reports indicated that NASA might submit an amended request to reflect current plans, but no budget amendment was submitted. Mr. O'Keefe has been quoted as estimating the cost of robotic servicing at between \$1 billion and \$1.6 billion, and NASA estimates the cost of robotic retrieval at about \$300 million. These estimates are bound to be imprecise, however, since possible designs are still under investigation and a final decision has not yet been made about which options to select.

Congressional Action. Because of the uncertainty about the future of Hubble, the House Appropriations Committee stated that it took "no action at this time with regard to funding for the Hubble program, but will re-evaluate the program's needs as they become more defined." The Senate Appropriations

²³ The announcement was made two days after President Bush's "Vision" speech, leading some to conclude that the decision not to service Hubble was linked to the need to redirect NASA spending to fund the Vision. NASA officials insist the Hubble decision was independent of the Vision, and was based on shuttle safety considerations and the need to use the shuttle to complete ISS. The decision is controversial and is discussed in CRS Report RS21767.

²⁴ National Research Council, *Assessment of Options for Extending the Life of the Hubble Space Telescope*, National Academies Press, 2005. [<http://books.nap.edu/catalog/11169.html>].

Committee provided an increase of \$300 million for Hubble: \$200 million in the Exploration, Science, and Aeronautics account and \$100 million in Exploration Capabilities. The Senate increase was designated as emergency spending. The conference agreement provided \$291 million for a Hubble servicing mission. Describing a successful servicing mission as “one of NASA’s highest priorities,” the conference report directed NASA to report to the appropriations committees within 90 days of enactment regarding the status of its plans.

Detailed Budget Issues

This section follows the format of the NASA budget as shown in the agency’s FY2005 budget estimate. The names of the two major budget accounts are different from FY2004, and, as discussed above, NASA’s management structure changed in August 2004, so some of the program offices described below no longer exist. These changes, and NASA’s shift to full cost accounting (discussed earlier), make it difficult to compare NASA’s budget across years other than at the total agency level.

Exploration, Science & Aeronautics (ES&A)

This budget account was entitled “Science, Aeronautics & Exploration” in FY2004 budget documents. The shift in the order of the words reflects NASA’s new emphasis on exploration in accordance with the Vision. The House Appropriations Committee declined to rename this category, stating that “While the committee is supportive of the exploration aspect of NASA’s vision, the Committee does not believe it warrants top billing over science and aeronautics.” (p. 128). The Senate Appropriations Committee agreed to NASA’s proposed change, but conferees adopted the House position. Thus, the account was not renamed.

In the FY2005 budget request, the ES&A account includes the Offices of Space Science, Earth Science, Biological and Physical Research, Aeronautics, and Education. The Offices of Space Science and Earth Science focus on increasing human understanding of space and Earth, and make use of satellites, space probes, and robotic spacecraft to gather and transmit data. The Office of Biological and Physical Research funds research conducted in microgravity environments to study fundamental principles of chemistry, biology, and physics, and that support human exploration of space. The Office of Aeronautics contributes to increasing air traffic capacity, reducing the impact of aircraft noise and emissions, improving aviation safety and security, and meeting other needs such as national defense and commercial competitiveness. The Office of Education funds programs aimed at educating children in elementary and secondary school, as well as university students, in science, mathematics, engineering, and technology.

For FY2005, NASA requested \$7.76 billion for ES&A, compared with \$7.83 billion appropriated for FY2004. See **Table 2** for a break-out of how the request is allocated to the different offices within this account. Part of the reduction from FY2004 results from the shift of a major program, Project Prometheus, from this account to the Exploration Capabilities account. Congress appropriated \$7.74 billion for this account. As noted, Congress allowed NASA to transfer funds between its

two major accounts, so the actual total NASA plans to spend on ES&A will not be known until it notifies Congress of its spending plans.

Space Science. The Office of Space Science (OSS) is responsible for NASA's Space Science Enterprise. OSS had five themes²⁵ in FY2004: Solar System Exploration, Mars Exploration, Astronomical Search for Origins, Structure and Evolution of the Universe, and Sun-Earth Connections. A sixth — Lunar Exploration — was added in FY2005 to support the Vision. Using primarily space-based telescopes and other sensing probes, OSS programs study the nature of stellar objects to determine their formation, evolution, and fate. Robotic probes are sent to other bodies in the solar system, searching for information about their composition and whether conditions for life exist. To accomplish these tasks, NASA supports a number of activities: a series of large, focused missions such as the Space Infrared Telescope Facility (SIRTF), Gravity Probe-B, and the Hubble Space Telescope (HST); the Explorer program to provide low-cost access to space with small, single purpose satellites; the Discovery program to support small solar system exploration missions; the New Frontiers program for planetary exploration probes in the \$650 million category; a Mars Exploration program; and, now, a Lunar Exploration program focused on providing information needed to support human trips to the Moon.

OSS also funds an extensive research and technology effort. The research component focuses on research and analysis, data analysis, and theoretical studies to interpret and understand space-based observations and provide scientific justification for future missions. This component also supports complementary ground-based and laboratory research and instrumentation activities. Universities and NASA field centers are the principal performers of supporting research.

FY2005 Budget Request and Congressional Action. For FY2005, NASA requested \$4.138 billion for the Office of Space Science, compared with a FY2004 appropriations level of \$3.971 billion. The request was allocated as follows: Solar System Exploration, \$1.187 billion; Lunar Exploration, \$70 million; Mars Exploration, \$691 million; Astronomical Search for Origins, \$1.067 billion; Structure and Evolution of the Universe, \$378 million; and Sun-Earth Connections, \$746 million.

The House Appropriations Committee cut all \$70 million for Lunar Exploration; \$12.4 of the \$12.5 million requested for science experiments for the Jupiter Icy Moons Orbiter (JIMO) in Solar System Exploration; \$5 million of the \$378 million for Structure and Evolution of the Universe; \$5 million of the \$47 million for Living with a Star, a Sun-Earth Connections program investigating the Sun's influence on Earth; and \$15 million from "other" technology and advanced concepts (there are several such line items in the OSS budget, it is not clear which of these is affected).

²⁵ Another layer of organizational identification created by Mr. O'Keefe is "themes" within each program office. There were a total of 18 themes in FY2004. The theme concept is explained in last year's edition of this report. Whether NASA will use themes as an organizational tool in the future is not clear.

The Senate Appropriations Committee cut \$50 million of the \$70 million for Lunar Exploration, \$50 million of the \$126 million for Mars Program Plans & Architecture, and may have cut funds for the JIMO science instruments, although language in the report is not clear. It added \$300 million for a servicing mission to the Hubble Space Telescope (designated as emergency spending), and \$25 million for Living with a Star.

Conferees did not specify an overall total for the Office of Space Science. Specific programs mentioned in the conference report are as follows: \$291 million for a Hubble servicing mission (discussed earlier, no funding had been requested); a cut of \$60 million from the \$70 million for Lunar Exploration (discussed earlier); and an addition of \$35 million to the \$47 million for Living with a Star. They also provided \$15 million for NASA to select competitively some of the instruments for the Terrestrial Planet Finder mission (a space telescope NASA plans to build).

Key Issue: Impact of the Vision. The key issues in the space science area in the FY2005 budget are the future of the Hubble Space Telescope (discussed above), and the possible impact of the decision to redirect NASA's activities to support primarily space science activities directly related to the Vision, rather than other space science projects.

Tensions have arisen between the scientific communities associated with the "themes" in the Office of Space Science that are included in the Vision, and those that are not. The themes that are included are Solar System Exploration, Mars Exploration, Lunar Exploration, and Astronomical Search for Origins. The other two themes, Structure of Evolution of the Universe (SEU) and Sun-Earth Connections (SEC), are not included, and in the FY2005 request, some of those projects were delayed or "indefinitely deferred." In the sand chart (discussed earlier, see Figure 3), SEU and SEC are relegated to the "other science activities" category that is flat-funded through FY2020. Supporters of those disciplines worry that budgets for their programs will suffer because of the emphasis on the Vision. The National Academies²⁶ released a report in October 2004 focused on demonstrating the importance of solar and space physics to the Vision. One of the missions that is indefinitely deferred in the FY2005 budget request, for example, is the Joint Dark Energy Mission, part of the "Beyond Einstein" program. JDEM was to be a joint mission with the Department of Energy to study "dark energy" in the universe, which is not well understood.²⁷ This project was one of the top priorities of the National Academies' list of interdisciplinary research.²⁸ The American Physical Society

²⁶ The National Academy of Science, the National Academy of Engineering, and the Institute of Medicine have collectively rebranded themselves "The National Academies." NASA often uses the National Academies to develop long-term research strategies for its scientific programs.

²⁷ For more information, see [<http://universe.gsfc.nasa.gov/science/darkenergy.html>].

²⁸ Brumfiel, Geoff. "NASA Casts a Shadow Over Bid to Illuminate Dark Energy." *Nature*, February 9, 2004, p. 667.

released a report on November 22, 2004 concluding that shifting funds to Vision-related projects “will mean neglecting the most promising space science efforts.”²⁹

As noted earlier, conferees on the FY2005 appropriations bill directed the National Academy of Sciences to conduct a “thorough review” of the science that NASA plans to undertake as part of the Vision, and develop a strategy by which all of NASA’s science disciplines — Earth science, space science, life and microgravity science, and science conducted aboard ISS — can make adequate progress towards their goals, and provide balanced scientific research in addition to supporting the Vision.

Earth Science. The Office of Earth Science (OES) is responsible for NASA’s Earth Science Enterprise. It has two themes: Earth Systems Science, and Earth Science Applications. OES supports programs that focus on the effects of natural and human-induced changes on the global environment. It seeks to answer the questions: How is the Earth changing, and what are the consequences for life on Earth?

NASA’s OES program constitutes the largest (in terms of funding) federally-supported activity studying the Earth and its environment. OES uses space-based, airborne, and ground-based instruments to acquire long-term data on the Earth system, and supports research and analysis programs that assist scientists in converting these data into knowledge. It also operates a data and information management system to capture, process, archive, and distribute data to the scientific community and the public. Another objective is development of remote sensing technologies that can be used to reduce the cost and increase the reliability of future Earth-monitoring missions.

The centerpiece of the Earth Science program is the Earth Observing System (EOS), a series of three spacecraft designed to monitor the Earth’s life-support systems. All three — Terra, Aqua, and Aura — are now in orbit. OES describes the EOS system as concurrently observing the major interactions of the land, oceans, atmosphere, ice, and life that comprise the Earth system. The EOS Data Information System (EOSDIS) collects, stores, processes, and transmits to researchers data from EOS spacecraft. NASA also launches smaller, more focused satellite missions called Earth Explorers that investigate particular phenomena. One example is Cloudsat, which is designed to improve cloud modeling, contribute to better predictions of cloud formation and distribution, and to lead to a better understanding of the role of clouds in Earth’s climate system. Within the Earth Science Applications program, NASA works with other agencies in applying the results of its earth science research to national priorities.

In 2001-2002, NASA reformulated its Earth Science program to align with President Bush’s Climate Change Research Initiative (CCRI) and the then-new strategic vision and mission enunciated by Administrator O’Keefe. Among the

²⁹ American Physical Society. Panel on Public Affairs. The Moon-Mars Program. November 2004. The report and a press release are available at [http://www.aps.org/public_affairs/index.cfm].

changes is a new focus on factors that may affect climate change other than carbon dioxide (CO₂), such as methane, aerosols, black carbon, and tropospheric ozone. NASA will now build an Advanced Polarimeter Instrument to study the non-CO₂ factors. In the FY2005 budget, this mission is called Glory. NASA was planning an EOS Follow-on series of satellites that would continue to collect data similar to that provided by the original EOS series in order to create a 15-year data set for scientists studying global change. They need long term observations using instruments gathering comparable data. The EOS Follow-on satellites are no longer part of OES's plans, however. Instead, the NPOESS Preparatory Project (NPP) is now OES' focus for obtaining continuity of Earth system science measurements. NPOESS is the National Polar Orbiting Environmental Satellite System being built by DOD, the National Oceanic and Atmospheric Administration (NOAA), and NASA as the future U.S. polar-orbiting weather satellite system (currently DOD and NOAA operate separate polar-orbiting weather satellite systems). NASA is developing technology for NPOESS and will test some of the new sensors on NPP.

OES was working with industry on a Landsat Data Continuity Mission (LDCM) to provide continuity of data from the Landsat series of satellites that have operated since 1972. (For more on Landsat, see CRS Issue Brief IB92011.) NASA hoped that the private sector, rather than the government, would build the next satellite, and the government would purchase the data it needed. Landsat 5 and 7, built and launched by NASA, are currently in orbit, though Landsat 5 is many years past its design lifetime, and both are only partially functioning. LDCM did not work, however. Only one bid was received and NASA rejected it. NASA is now considering adding Landsat-type sensors to NPOESS.

FY2005 Budget Request and Congressional Action. NASA requested \$1.485 billion for Earth Science in FY2005, compared with a FY2004 appropriation of \$1.613 billion. The \$1.485 billion request was allocated as follows: Earth System Science, \$1.409 billion; and Earth Science Applications, \$77 million.

The House Appropriations Committee cut \$20 million of the \$54 million for the Glory mission, and \$15 million of the \$45 million for the Orbiting Carbon Observatory, which is to provide global CO₂ measurements.

The Senate Appropriations Committee added \$15 million to the \$77 million requested for Earth Science Applications.

Conferees did not specify a total for Earth Science. They added \$15 million to the \$77 million for Earth Science Applications. They also provided \$15 million for the EOSDIS Core System (ECS) Synergy program that assists NASA and university researchers in using EOS data.

Key Issue: Impact of the Vision. Plans for Earth Science may change again in response to the Vision. The funding projections for Earth Science submitted with the FY2005 budget request show a constrained budget for these activities, and, as discussed earlier, the Office of Earth Science was combined with the Office of Space Science in the August 2004 reorganization. These two actions are seen by Earth science advocates as signs of a diminished status for this scientific discipline at NASA, and they expect intense competition for funds within the new Science

Mission Directorate. Others point out that Space Science and Earth Science were part of the same office until a NASA reorganization in the early 1990s (it was called the Office of Space Science and Applications at that time), and does not necessarily indicate a reduced stature.

Biological and Physical Research. The Office of Biological and Physical Research (OBPR) is responsible for NASA's Biological and Physical Research Enterprise. It has responsibility for three themes: Biological Sciences Research, Physical Sciences Research, and Research Partnerships & Flight Support. OBPR's goals include determining ways to make human habitation of space safe, and to use space as a laboratory to test fundamental principles of chemistry, biology, and physics. OBPR supports a number of programs that investigate the biomedical effects of space flight and the effects of gravity on biological processes, develop technologies to support humans living in space, and enhance space crew health and safety. Research activities sponsored by OBPR are carried out on the space shuttle, on the ISS, as well as on aircraft and suborbital vehicles, and in ground-based laboratories.

FY2005 Budget Request and Congressional Action. For OBPR, NASA requested \$1.049 billion for FY2005, compared with \$985 million in FY2004. The \$1.049 billion request was allocated to the three themes as follows: Biological Sciences Research, \$492 million; Physical Sciences Research, \$300 million; and Research Partnerships & Flight Support, \$257 million.

The House Appropriations Committee cut \$103 million from the \$309 million requested for bioastronautics research.

The Senate Appropriations Committee cut \$123.5 million from the request for Biological Sciences Research, of which bioastronautics research is a part.

Conferees did not specify a total for OBPR or the activities it conducts. In commenting on the Vision, they did request the National Academy of Sciences to conduct a "thorough review" of the science that NASA plans to undertake as part of the Vision, and develop a strategy by which all of NASA's science disciplines — including science conducted aboard ISS — can make adequate progress towards their goals, and provide balanced scientific research in addition to supporting the Vision.

Key Issue: Impact of Columbia, and the Vision. OBPR's budgeting and planning were affected first by the space shuttle *Columbia* tragedy, and then by the Vision. *Columbia*'s 16-day scientific research mission (STS-107) hosted experiments sponsored in large part by OBPR. Other OBPR research is conducted on the ISS, whose schedule and utilization is affected by the accident as well, especially by the reduction in crew size to two people, and the inability to take new experiments to ISS (they are designed to go on the shuttle). Perhaps most significantly, however, was the decision to refocus ISS research only on life sciences research needed to support the Vision, instead of the broadly-based research program that was originally planned. The elimination of OBPR in the August 2004 reorganization also is seen as indicative of the changed status of this field of research in the agency. It is not yet clear what will remain of the OBPR ISS-based research

program, and how it will fare in competing with other priorities in the new Exploration Systems Mission Directorate.

Aeronautics Research. The Office of Aeronautics was created when the Office of Aerospace Technology was divided into the Office of Exploration Systems and the Office of Aeronautics after the President's "Vision" speech. 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." The aeronautics technology theme consists of programs in vehicle systems, airspace systems, and aviation safety and security. In FY2003, NASA called this theme "Revolutionize Aviation." In FY2001 and FY2002, aeronautics R&D was integrated with space transportation activities in combined Technology Base and Focused aerospace programs.

FY2005 Budget and Congressional Action. The FY2005 request for aeronautics was \$919 million, a reduction of 11% from FY2004. Most of the reduction comes from eliminating funds for items added at congressional direction in FY2004. Other changes include a \$7 million increase for aircraft noise reduction and \$15 million to fund rotorcraft research. The House Appropriations Committee directed NASA to develop "a prioritized set of aeronautics goals through 2020" along with associated annual funding requirements. It also directed NASA to provide \$25 million for Intelligent Propulsion System Foundation Technologies (Propulsion 21), for advancements in jet engines. The Senate Appropriations Committee provided \$25 million to continue research on hypersonic engine technologies. The conference agreement contained the House language, and provided \$25 million for continued design work on the hypersonic X-43C aircraft. It is not clear if that the report language saying that the committee or conferees have "provided" the funding means that it is an addition to requested funding, or a direction that NASA on how to spend appropriated funds. It also expressed concern about the impact of full-cost accounting on the operation of NASA's wind tunnels.

Key Issue: Funding. Congress has expressed concern about constraints in NASA's funding for aeronautics R&D for several years. The need to reprioritize NASA spending in light of the Vision may exacerbate those concerns. Aeronautics advocates decry a multi-year slide in funding, although this trend has been difficult to track recently because of changes in how NASA presents its annual budget. Aeronautics R&D at NASA was cut by about one-third in the late 1990s, with the termination of programs in high-speed research and advanced subsonic technology. NASA's aeronautics activities have been restructured several times, including the August 2004 reorganization noted above. Critics have argued for several years that NASA lacks a clear vision of its goals and direction in aeronautics, despite release of the *NASA Aeronautics Blueprint* [http://www.aerospace.nasa.gov/aero_blueprint/] in February 2001 and further recommendations by the congressionally established Commission on the Future of the United States Aerospace Industry ([<http://www.ita.doc.gov/td/aerospace/aerospacecommission/aerospacecommission.htm>]) and the National Research Council ([<http://books.nap.edu/html/atp/0309091195.pdf>]).

Education. The Office of Education is responsible for the Education Enterprise. It has one theme: Education Programs. Prior to FY2004, the activities in the Office of Education appeared under the budget heading “Academic Programs.” NASA reorganized these activities in 2003, consolidating programs that had been in its Office of Human Resources & Education, and the Office of Equal Opportunity Programs, into the new Office of Education. The other five NASA Enterprises also fund and manage educational activities as part of specific space flight projects they sponsor. The educational activities of the other Enterprises are coordinated by the Office of Education. 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,³⁰ the National Institutes of Health, the Department of Defense, and the Department of Energy.

NASA Administrator O’Keefe continues to stress the importance of education at NASA, but the August 2004 reorganization abolished the Office of Education, which he had created just one year earlier. Instead he appointed a “Chief Education Officer” who reports to the Deputy Administrator. What impact, if any, this has on funding or activities related to education remains to be seen.

³⁰ 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.

FY2005 Budget Request and Congressional Action. NASA requested \$169 million for the Office of Education in FY2005, compared with \$226 million in FY2004. The difference in the two amounts can largely be attributed to congressionally directed funding added to the FY2004 budget for which NASA is not requesting further funding.

The House Appropriations Committee report added \$9 million for the Space Grant Program, and \$7.4 million for EPSCoR. The Senate did not make recommendations about those programs. Conferees added \$9.1 million for Space Grant, bringing the total appropriations to \$28.2 million. They added the \$7.4 million recommended by the House for EPSCoR, bringing that total to \$12 million.

Exploration Capabilities

In the FY2004 budget, this account was entitled “Space Flight Capabilities.” The new name reflects the importance accorded to exploration following President Bush’s speech. In the FY2004 budget, there were two subcategories: “Crosscutting Technologies” through which new launch vehicles and an Orbital Space Plane were being developed, along with technology transfer and small business innovation activities. In the FY2005 budget, these are labeled “Exploration Systems.” The other subcategory, Space Flight, retains the same name in FY2005, and includes the International Space Station and the space shuttle programs, along with Space Flight Support (such as purchasing launches on expendable launch vehicles).

For FY2005, the request for Exploration Capabilities was \$8.456 billion, compared with \$7.521 billion in FY2004. Part of the increase can be attributed to the shift of Project Prometheus into this account from the Office of Space Science. Conferees appropriated \$8.426 billion for this account, but allowed NASA to shift funds between this account and the ES&A account. Thus the total that NASA will allocate for this account will not be known until the agency notifies Congress of its spending plans.

Exploration Systems. This budget category replaces what was called “Crosscutting Technologies” in the FY2004 budget. It has two themes: Human & Robotic Technology, and Transportation Systems. Crosscutting Technologies was focused on the Space Launch Initiative (see below), which has been terminated. Last year’s subcategories of “Mission and Science Measurement Support” (MSM) and “Innovative Technology Transfer Partnerships” were absorbed in the new “Human & Robotic Technology” subcategory. MSM was renamed “Advanced Space Technology.”

This new program office would be the focal point for implementation of the Vision. Its activities include developing a new spacecraft to take astronauts to the Moon (the Crew Exploration Vehicle), the Centennial Challenges program through which NASA will offer “prizes” for development of new technologies to support the Vision, and Project Prometheus, for development of space nuclear power and propulsion systems. It also inherited activities that were included in the former Office of Aerospace Technology related to development of advanced space technologies, and technology transfer.

The FY2005 request signaled NASA's intent to terminate the Space Launch Initiative (SLI). In FY2004, SLI consisted of the Orbital Space Plane (OSP) and the Next Generation Launch Technology (NGLT) programs. OSP had begun only a year earlier, and was intended to build a spacecraft to take astronauts to and from the ISS. NGLT was to develop technologies to build new expendable or reusable launch vehicles, having absorbed what remained from the November 2002 restructuring of the 2nd and 3rd generation RLV programs, and other launch-related technologies. NASA officials assert that they do not know a new launch vehicle will be needed for the Vision, and hence no funding is included for one in the FY2005 request. However, the "sand chart" (discussed earlier) includes \$13-16 billion in FY2011-2020 to build a new launch vehicle.

FY2005 Budget Request and Congressional Action. NASA requested \$1.782 billion for Exploration Systems. The funding was split between two themes: Human & Robotic Technology, \$1.093 billion; and Transportation Systems, \$689 million. Human & Robotic Technology includes Technology Maturation (for various technology development activities related to the Vision), Project Prometheus (to develop space nuclear power and propulsion systems), Advanced Space Technology (formerly Mission and Science Measurement Support), Innovative Technology Transfer Partnerships (ITTP), and Centennial Challenges (described above). Transportation Systems includes the Crew Exploration Vehicle (CEV) to take astronauts to and from the Moon, and termination funds for the Space Launch Initiative (SLI).

Congressional action on the Vision is discussed earlier in this report. To recap, the House Appropriations Committee eliminated all funds for the CEV (\$438 million), cut \$230 million from the \$438 million for Project Prometheus, cut \$100 million from the \$261 million to terminate the SLI program to accelerate termination, and cut \$30 million of the \$115 million for technology maturation. The Senate Appropriations Committee cut \$160 million from CEV, cut all \$115 million from technology maturation, cut \$10 million of the \$20 million for Centennial Challenges, and cut Project Prometheus by \$8 million. Conferees did not specify funding amounts for these activities.

The House also added \$30 million to the \$161 million for the ITTP Program "for the express purpose of continuing the commercial programs, including the activities of associated NASA personnel, as they existed in FY2003 and prior fiscal years." Conferees adopted that action.

Key Issue: Crew Exploration Vehicle (CEV). The CEV is one of the centerpieces of the Vision. It is a spacecraft that will be used to take astronauts to and from the Moon, although it could also be used to take them to and from ISS. It is the latest iteration of NASA's concept for what new spacecraft it wants to build to replace the shuttle as a vehicle capable of taking astronauts to space. (It would not replace the shuttle's cargo-carrying capabilities.)

NASA is using the “spiral development” philosophy for CEV, which is used for some DOD R&D programs.³¹ This can be considered a “build a little, test a little, build a little, test a little” approach to R&D, where one accepts that the early versions of a spacecraft (or other product) may not have the full capability envisioned. The President’s speech directs NASA to develop and test a new spacecraft by 2008 and that the first flight carrying a crew to Earth orbit take place by 2014. NASA is proceeding quickly with getting contractors to submit proposals for the CEV in order to meet those dates. Skeptics wonder whether it will be possible to have any version of the vehicle ready by 2008, especially when basic decisions such as the number of astronauts it needs to carry are yet to be made.

As discussed earlier, conferees did not specify a level of funding for the CEV. They expressed concern 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, within 60 days of the bill’s enactment. 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 independent oversight committee is to report to the NASA Administrator and the appropriations committees on their findings and recommendations.

Another major issue involving CEV is the potential four-year gap between when the space shuttle would be terminated (2010), and the CEV would be ready for Earth orbital missions (2014). That issue is discussed below (see **Space Shuttle**).

Space Flight. The Office of Space Flight supports the Space Flight Enterprise (formerly the Human Exploration and Development of Space Enterprise). Space Flight has three themes: International Space Station, Space Shuttle, and Space Flight Support. NASA requested \$6.674 billion for this category, allocated as follows: \$1.863 billion for the ISS; \$4.319 billion for the space shuttle; and \$492 million for Space Flight Support.

International Space Station. The International Space Station (ISS) has undergone many changes since it was first proposed by President Reagan in 1984. For the last several years, its primary purpose was described as serving as a scientific research facility for conducting a range of research activities in biology, physics, and materials science. NASA expected that research performed in the near-zero gravity environment of the space station would result in new discoveries in life sciences, biomedicine, and materials sciences. Under the Vision, however, the research program on ISS is being redirected to focus only on the life sciences research needed to accomplish the Vision, not the broadly based scientific research program that was planned.

³¹ For more on spiral development, see CRS Report RS21195, *Evolutionary Acquisition and Spiral Development in DOD Programs: Policy Issue for Congress*, by Gary J. Pagliano and Ronald O’Rourke.

As noted earlier, ISS is being built as a partnership among the United States, Russia, Japan, Canada, and Europe. An Intergovernmental Agreement (IGA) among the various governments, and Memoranda of Understanding (MOUs) between NASA and its counterpart agencies, govern the program.³² The ISS is being assembled in orbit. Assembly of ISS began in 1998 and is now suspended pending the space shuttle's return to flight.

A new category in the ISS budget in FY2005 is called "ISS Crew/Cargo Services." It would fund commercial or foreign alternatives to the shuttle for taking crews and cargo to ISS. NASA officials have indicated that they would use this line item to fund, for example, the purchase of Soyuz spacecraft (or services) from Russia for transporting U.S. crews. However, under the 2000 Iran Nonproliferation Act (INA), NASA is prohibited from paying money to Russia for ISS-related purchases unless the President certifies that Russia is not transferring certain nuclear and missile technologies to Iran. The funding in this category also may be used to fund commercial companies to develop launch vehicles and spacecraft capable of taking cargo to, and possibly from, ISS once the shuttle system is retired.

FY2005 Budget Request and Congressional Action. The FY2005 budget request for the ISS program was \$1.863 billion, compared with \$1.498 billion in FY2004. The funding requested in this "International Space Station" budget line is for construction and operation of the ISS, and the new ISS Crew/Cargo Services line described above. Of the \$1.863 billion requested, \$140 million was for ISS Crew/Cargo Services. Customarily, NASA agrees that the costs for research aboard the station, currently carried in the OBPR budget, also are part of the space station request. Over time, these costs variously have been placed in OBPR, or in the ISS account. Since FY2003, they have been in the OBPR budget. In FY2005, that request was \$549 million. If the two amounts are added, the total request for ISS in FY2005 was \$2.412 billion.

The House Appropriations Committee cut \$190 million from ISS: \$120 million from the traditional line item that includes construction and operations, plus \$70 million from the new ISS Crew/Cargo Services line. The Senate committee cut the same \$120 million, plus all \$140 million from ISS Crew/Cargo Services, for a total cut of \$260 million. Both committees also made cuts to the science accounts associated with research on ISS (see OBPR, above). Conferees did not specify funding amounts for ISS.

Key Issue: Long Term Future of ISS. Twenty years after the space station program began, the purpose of the space station continues to be questioned. The Bush Administration's Vision-related decisions necessitate a reassessment of the rationale for ISS. The Vision calls for NASA to (1) end its use of ISS by FY2017, six years after construction is expected to be completed, (2) terminate shuttle missions after construction is completed meaning that there is no guaranteed access to ISS by U.S.

³² The texts of these agreements are available at [<http://www.hq.nasa.gov/office/codei/>] by scrolling down to the heading "Related Internet Resources" and looking at the second and fourth bullets "Other NASA Links."

astronauts after 2010, and (3) limit its research only to that which is needed for the Vision instead of the broad research program that was planned.

Various rationales for building a space station have been put forward by NASA over the years, but the one that has remained relatively constant is the utility of a space station as a microgravity research laboratory. NASA was planning a wide-ranging research program covering disciplines in the physical and biological sciences using three laboratory modules: NASA's Destiny module (already in orbit), Europe's Columbus module (construction is completed and it is awaiting launch), and Japan's Kibo module (construction on the pressurized portion of the module is completed). Under the agreements that govern the ISS program, NASA can use 46.7% of the research capacity of Columbus and Kibo in exchange for the electrical power and other ISS services provided to Europe and Japan by NASA.

The extent to which the research capabilities of ISS can be fully utilized depends in part on how many crew members are available to conduct research. A considerable amount of crew time must be spent on maintenance tasks. Prior to the *Columbia* accident, when ISS had three-person crews, NASA stated that it took 2½ crew members to operate ISS, leaving the equivalent of one-half of one crew member's time for research. Since *Columbia*, while crews have been reduced to two to reduce resupply requirements, NASA has been less clear about how much crew time is spent on maintenance versus research.

Whatever the case may be today, the plans were for crew size to grow to seven by the time full operations began after assembly is completed. Three of those crew slots would go to Russia, and the other four to the United States, Europe, Canada, and Japan. The crews would be transported by Russia's three-person Soyuz spacecraft, and NASA's shuttle, which typically carries seven. Emergency crew return ("lifeboat") services were to be provided by Russia (for three people) and NASA (for at least four people).

U.S. decisions have placed in doubt, however, the extent to which the crew size can grow beyond three — the number that can be returned to Earth in an emergency by a single Soyuz spacecraft. The U.S. decided not to build its own emergency crew return vehicle, and passed a law, the Iran Nonproliferation Act (INA, P.L. 106-178), under which NASA cannot pay Russia for space station-related activities such as providing additional Soyuz spacecraft unless the President certifies to Congress that Russia is not proliferating nuclear or missile technology to Iran. Having two Soyuzes always docked at ISS would provide the requisite lifeboat services for a six person crew, but the international partners have not been able to reach agreement on how to pay for the additional Soyuzes. Russia has warned the ISS partners for many years that it does not have sufficient funding to build that many (once a Soyuz is in orbit, it must be replaced in six months, so four per year would be needed). So unless the President certifies that Russia is in compliance with the act, one of the other partners pays for more Soyuzes, or Russia decides to provide more Soyuzes without further cash payments from NASA, crew size will be limited to no more than three. (See CRS Issue Brief IB93017, *Space Stations*, by Marcia Smith, for more on the ISS program and the INA.)

President Bush's directive to limit NASA's research on ISS to only that which is required to achieve the Vision is another change. The two major life sciences research areas related to the Vision are studying human adaptation to weightlessness, and radiation protection. The type of radiation to which astronauts would be exposed away from Earth's protective atmosphere, however, is different from the type in low Earth orbit, so the radiation research is conducted largely using ground-based facilities, not the ISS. That leaves only research on adaptation to weightlessness for ISS-based studies. That research is most relevant to human missions to Mars. The Moon is sufficiently close that the crew spends only a short time (about three days one-way) in weightlessness. But journeys to Mars are much longer. Mars trip durations would vary depending on the relative orbital positions of the Earth and Mars, the length of time the crew would stay on the Martian surface, and whether chemical propulsion or nuclear thermal propulsion is used. A 1991 study by the White House National Space Council concluded that a typical mission to Mars using chemical propulsion would take 224 days to reach Mars, and 237 days to return to Earth (with 458 days on Mars). Using nuclear thermal propulsion, it stated that a typical mission would be 160 days to Mars and 160 days to return (with 550 days on the surface).³³ The near-zero gravity (g) conditions on ISS provide an environment for studying adaptation to the conditions astronauts would encounter between Earth and Mars. (Mars has 1/3 g, and the Moon has 1/6 g, so it is not clear that the zero-g research would be applicable to stays on the Martian or lunar surface.)

NASA officials have indicated that they need approximately 200 human research subjects to spend no less than four months at a time on ISS in order to conduct the research on adaptation to weightlessness. How to accomplish that in the short period of time during which NASA now plans to use the ISS, with a crew size that may be limited to no more than three people, is an open question.³⁴ It is not clear how many U.S. astronauts will be able to remain on ISS for missions that last at least four months once Russia fulfills an existing obligation to provide crew return ("lifeboat") services for U.S. astronauts in spring 2006. NASA and Russia are discussing how to proceed after that time, but absent a new agreement, U.S. astronauts may only be able to be aboard ISS when the shuttle is docked. The shuttle missions typically remain for about two weeks, well short of the four-month requirement. If the shuttle is retired in 2010 as directed by the President, NASA will not be able to launch astronauts to ISS at all until the CEV is available. Thus, any weightlessness research could be dependent on foreign crews *if* they agree to be research subjects. Even if all agreed to do so, it is questionable as to whether the requisite number of people would cycle

³³ The White House. National Space Council. *America at the Threshold: Report of the Synthesis Group on America's Space Exploration Initiative*. Washington, U.S. Govt. Print. Off., 1991. p. 21. This report was done in connection with President George H.W. Bush's proposal to send astronauts back to the Moon and on to Mars. The senior President Bush's proposal is discussed in CRS Report RS21720.

³⁴ Vision-related documentation, such as the sand chart, and briefings by NASA officials, indicate that NASA will complete its use of ISS by FY2017 in order to free funding for the Vision. However, Mr. O'Keefe said at a February 12, 2004 House Science Committee hearing that there are no plans to "turn out the lights" at that time because the other partners might continue to use ISS, "and we may too."

through ISS by the time NASA completes its use of the facility, especially since the Soyuz-based missions last six months, reducing opportunities for crew-rotations.

Since FY1985, U.S. taxpayers have spent more than \$30 billion on ISS,³⁵ and it is expected that the program will continue to need approximately \$2 billion per year for the next several years. By deciding to limit research to only that which is needed to send astronauts to Mars, NASA appears to have conceded what some scientists have argued since the beginning of the program — that the only research for which a space station is needed is that related to future human space exploration, not to Earth-based benefits such as curing diseases or developing new materials or purer pharmaceuticals as claimed by NASA for these many years. Thus the debate over further spending on ISS may be reignited.

Barring a catastrophe on the ISS, a Soyuz, or on the shuttle once it returns to flight, it nonetheless appears that NASA and its partners are determined to continue construction of ISS. How much of it will be built, and how long it will be used, remain unanswered questions.

Space Shuttle. The space shuttle is a partially reusable launch vehicle capable of taking crews and cargo to and from space. It is the only U.S. launch vehicle currently capable of placing humans in space. The shuttle system consists of the airplane-like orbiter, two solid rocket boosters (SRBs) on either side, and a large cylindrical “external tank” that holds the fuel for the orbiter’s engine. The orbiters are reusable, and were built for 100 flights each. The SRBs provide additional thrust for the first 2 ½ minutes of flight, then detach from the vehicle and fall into the ocean where they are recovered and refurbished for reuse. The External Tank (ET) is not reusable. It contains liquid hydrogen and liquid oxygen to fuel the orbiter’s engines. The fuel is depleted by the time the orbiter reaches orbital altitude (approximately 8 minutes after launch), at which time the ET is jettisoned. It breaks apart as it descends from orbit, and the pieces fall into the Indian Ocean. Three space shuttle orbiters remain in the fleet: *Discovery*, *Atlantis*, and *Endeavour*. Three others were built. *Enterprise* was built for atmospheric tests in the 1970s. It was not designed to be flown in space, and has been transferred by NASA to the Smithsonian Institution. *Challenger* was destroyed in a 1986 tragedy, killing seven astronauts. The 2003 *Columbia* tragedy already has been discussed.

In 1995, NASA decided to turn most shuttle operations over to a “single prime contractor” and awarded a sole source contract to the United Space Alliance (USA), a limited liability company owned 50-50 by Boeing and Lockheed Martin, to pull

³⁵ Taxpayers in Canada, Europe, and Japan have spent more than \$10 billion on their contributions to ISS. A reliable figure for Russian expenditures is not available. Canada built the remote manipulator system, part of which is already in orbit (the “arm”) and another part (SPDM, or the “hand”) is awaiting launch; Europe and Japan have built laboratory modules and other space station elements, which are awaiting launch. Russia built, at its own expense, the module that serves as crew quarters and a docking module, and provides routine flights of its Soyuz spacecraft to transport crews to and from ISS, and Progress spacecraft to take cargo to ISS. Russia plans to build other modules and an electricity-generating array. Today, the space station is completely dependent on Russia for crew and cargo transport while the shuttle is grounded.

together the 86 separate contracts with 56 different companies under which the shuttle program was then operating. NASA signed a \$7 billion, six-year Space Flight Operations Contract (SFOC) with USA on September 26, 1996 with the goal of reducing shuttle operational costs while ensuring safety. NASA has exercised two contract options extending the contract to 2006. NASA has not yet incorporated contracts for the External Tank, Solid Rocket Boosters, and Space Shuttle Main Engines into SFOC. NASA manages those contracts, with Lockheed Martin, ATK Thiokol, and Boeing Rocketdyne, respectively.

FY2005 Budget Request and Congressional Action. The FY2005 shuttle budget is discussed earlier in this report (see **Key NASA Budget Issues: Return to Flight of the Space Shuttle**). Essentially, NASA requested \$4.3 billion in its February 2004 budget request, and in November 2004 informed Congress that it will need an additional \$762 million for FY2005 to support the shuttle program. The House and Senate Appropriations Committees fully funded the February request. The Senate committee recommended an additional \$500 million in emergency spending. Conferees provided the \$4.3 billion requested, and noted that NASA could request supplemental funding, or transfer funds from other NASA activities, if needed.

Key Issue: How Long the Shuttle Should Operate. Apart from the issues related to return to flight discussed earlier in this report, there remains the question of how long to fly the shuttle after RTF is achieved, and what, if anything, should replace it. (Another part of the debate is whether the shuttle should be used to service the Hubble Space Telescope. That issue is addressed earlier in this report.)

NASA, sometimes jointly with the Department of Defense (DOD), has been trying to build a replacement for the shuttle since the early 1980s. Those attempts have failed, however. Overly optimistic expectations about the availability of new technologies, and about the market for such a “2nd generation” reusable launch vehicle (RLV), are often cited as reasons for the failures of the National Aero-Space Plane, X-33, X-34, and Space Launch Initiative (SLI) programs. The shuttle is the “1st generation” RLV, and was expected to significantly reduce the cost of launching people and cargo into space because of its reusability. Those cost reductions have not materialized, however.

Until the announcement of the Vision, the expectation was that the shuttle would operate until some type of replacement was available. In November 2002, NASA shifted its strategy from building a new RLV, to building an “Orbital Space Plane” that would be launched on an Expendable Launch Vehicle (ELV),³⁶ similar to the Mercury, Gemini, and Apollo programs. But the Vision terminated the Orbital Space Plane program as well. Instead, the focus now is on a Crew Exploration Vehicle (CEV, discussed earlier), but its purpose is to take crews to the Moon, not to the ISS. NASA allows that it may be used for space station missions, but that is not its primary purpose. There is a four-year “gap” between when the President plans to terminate

³⁶ ELVs are “expendable” in that they can only be used once. All launch vehicles in the world are ELVs, with the exception of NASA’s space shuttle. The Soviet Union attempted to develop its own space shuttle, Buran, but it flew only once, without a crew, in 1988. The program was abandoned for cost reasons when the Soviet Union collapsed.

the shuttle program (2010) and when the CEV will be available for Earth-orbital flights (2014). Thus, if the Vision is adopted, the United States will have chosen to eliminate its ability to place humans into space, and rely on Russia to provide those services for at least four years. The price and other terms (such as how often Americans could fly, and how long they would have to stay on the space station³⁷) Russia would require for those services have not been negotiated. Although there was a six-year period from 1975-1981 when the United States also did not have the ability to place humans in space, this decision is different in that an inability to place U.S. astronauts on the ISS could impact achievement of the Vision because there would be fewer research subjects for weightlessness studies (discussed earlier). Therefore, one part of the Vision (ending assured U.S. access to the space station), could negatively impact another part of the Vision (sending astronauts to Mars).

Some Members of Congress want more dramatic changes to the shuttle program. Senator Brownback, chairman of the Senate Commerce, Science, and Technology subcommittee that oversees NASA, for example, has suggested that the shuttle be discontinued as soon as possible so the funding resources can be used to accelerate the schedule for the Vision, and asked NASA to study alternatives to the shuttle for completing the ISS program.³⁸ Representative Barton, a member of the House Science Committee (and Chairman of the House Energy and Commerce Committee) insisted that the shuttle is not safe enough for crews and should only be used in an automated mode with no crews aboard. In September 2003, he said "... I am going to do everything I can within the rules of this committee and the House to prevent more Americans going up in the existing orbiters. I just think it's inherently unsafe."³⁹

According to press reports, NASA itself is reassessing how many shuttle flights should be flown after RTF. NASA's early estimate was that 25-30 flights over six years (2005-2010) are needed both to deliver the remaining segments of ISS to orbit, and to pre-position replacement parts and supplies that were planned to be taken to the ISS on an as-needed basis during the operational phase of the program. According to *Space News*, NASA's current estimate is 28 flights, but the agency is reviewing how many of those are "absolutely essential."⁴⁰

Conversely, others expect that completing ISS assembly will take longer than six years, and expect the shuttle to continue flying beyond 2010. The President of ATK Thiokol, which makes the shuttle's SRBs, was quoted as saying that "All outside

³⁷ Currently, crews are rotated on six-month schedules, but Russia wants to increase that to one-year. NASA responded that it is not yet ready to move to one-year missions for its astronauts.

³⁸ U.S. Senate. Committee on Commerce, Science, and Transportation. *Future Space Flight*. Hearing. May 5, 2004. 108th Congress, 2nd sess. Transcript provided by Federal Document Clearing House (via Factiva).

³⁹ U.S. Congress. House. Committee on Science. *NASA's Response to the Columbia Report*. Hearing. September 10, 2003. 108th Congress, 1st sess. Washington, U.S. Govt. Print. Off., 2004. pp. 36-37.

⁴⁰ Berger, Brian. "Debate about Shuttle's Future Heats Up." *Space News*, November 1, 2004, pp. 1, 3.

experts ... believe the existing program has to fly through 2014.”⁴¹ If true, this could become an issue for Congress because the CAIB stated that if the shuttle is to continue in service beyond 2010, it should be “recertified.” It is not clear what that process would involve, or how much it would cost. A NASA shuttle official has stated that the current Return to Flight effort will produce a shuttle system that is certified for whatever period of time it is needed. Whether all stakeholders agree with that assessment or not is unknown.

Still others want to keep the shuttle flying until the United States has another method of taking astronauts to orbit. Senator Kay Bailey Hutchison and Senator Bill Nelson have both expressed concern about a plan in which the shuttle is terminated and the CEV is not yet available, particularly since development programs often take longer than planned, so the gap may be even more than four years.⁴²

Thus, there are several potential futures for the shuttle: immediate termination, termination after a minimal number of ISS flights, termination after 25-30 ISS flights, or termination only after the United States has another vehicle capable of taking crews into space. It is not clear today which of these paths the shuttle program will follow, although, considering the effort being put into RTF activities, it appears unlikely that immediate termination will be chosen. How much longer the shuttle will fly after that will depend on many factors, including whether NASA can demonstrate that the risks inherent in the shuttle program are manageable (another catastrophic accident would very likely bring an end to the program), how much it costs and how much NASA has to spend on it, and the extent to which policy makers want the United States to have its own ability to place astronauts in space instead of relying on Russia.

Considering that the space shuttle program consumes 25% or more of NASA’s budget, the answer could be key to what other activities NASA can support.

Space and Flight Support. This budget category includes space communications, space shuttle payload processing, expendable launch vehicles, rocket propulsion systems testing, environmental activities (dismantling of the Plum Brook nuclear facility and environmental compliance and restoration), and advanced systems programs.

FY2005 Budget Request and Congressional Action. The FY2005 request was \$492 million, compared with \$432 million in FY2004. No major changes were made in this account by the House or Senate Appropriations committees. Conferees did not specify an amount for this budget category.

⁴¹ Quoted in: Berger, “Debate about Shuttle’s Future Heats Up.”

⁴² U.S. Senate. Committee on Commerce, Science, and Transportation. *NASA’s Space Shuttle Program*. Hearing. September 8, 2004. 108th Congress, 2nd sess. Transcript provided by Federal Document Clearing House (via Factiva).

Out-Year Budget Projections

NASA's FY2005 budget estimate contains the out-year budget projections shown in **Table 6**. Such projections are always subject to change, but can be indicative of the direction in which the Bush Administration wants NASA to head. In this case, it represents the budget the Bush Administration expects to request to begin implementation of the Vision. NASA initially would receive approximately 5% increases, but then would receive increases that are less than the expected 2.1% rate of inflation.

Table 6. FY2005-2009 NASA Funding Projection
(in \$ millions)

Category	FY2005	FY2006	FY2007	FY2008	FY2009
Exploration, Science, & Aeronautics	7,760	7,869	8,320	8,900	9,091
— Space Science	4,138	4,404	4,906	5,520	5,561
— Earth Science	1,485	1,390	1,368	1,343	1,474
— Biol. & Phys. Res.	1,049	950	938	941	944
— Aeronautics	919	957	938	926	942
— Education	169	169	171	170	170
Exploration Capabilities	8,456	9,104	9,465	9,070	8,911
Exploration Systems	1,782	2,579	2,941	2,809	3,313
— <i>Human & Robotic Tech.</i>	<i>1,094</i>	<i>1,318</i>	<i>1,317</i>	<i>1,386</i>	<i>1,450</i>
— <i>Transportation Systems</i>	<i>689</i>	<i>1,261</i>	<i>1,624</i>	<i>1,423</i>	<i>1,863</i>
Space Flight	6,674	6,525	6,524	6,261	5,598
— <i>Space Station*</i>	<i>1,863</i>	<i>1,764</i>	<i>1,780</i>	<i>1,779</i>	<i>2,115</i>
— <i>Space Shuttle</i>	<i>4,319</i>	<i>4,326</i>	<i>4,314</i>	<i>4,027</i>	<i>3,030</i>
— <i>Space Flight Support</i>	<i>492</i>	<i>435</i>	<i>430</i>	<i>456</i>	<i>453</i>
Inspector General	28	29	30	31	32
Total	16,244	17,002	17,815	18,001	18,034
Year-to-year increase (%)	5.6	4.7	4.8	1.0	0.2

Source: FY2005 NASA Budget Estimate, page 1.

The “sand chart” (**Figure 2**) is a graphical representation of how the Bush Administration sees the NASA budget developing through FY2020.

Appendix A. Related CRS Reports

General

CRS Issue Brief IB92011, *U.S. Space Programs: Civilian, Commercial and Military*, by Marcia Smith.

CRS Issue Brief IB93017, *Space Stations*, by Marcia Smith.

CRS Issue Brief IB93062, *Space Launch Vehicles: Government Requirements, Commercial Competition, and Satellite Exports*, by Marcia Smith.

The Vision for Space Exploration

CRS Report RS21720, *Space Exploration: Overview of President Bush's New Exploration Initiative for NASA, and Key Issues for Congress*, by Marcia Smith.

CRS Report RS21866, *Report of the Aldridge Commission on Implementation of President Bush's Exploration Initiative*, by Marcia Smith.

The Columbia Accident

CRS Report RS21408, *NASA's Space Shuttle Columbia: Quick Facts and Issues for Congress*

CRS Report RS21606, *NASA's Space Shuttle Columbia Synopsis of the Report of the Columbia Accident Investigation Board*, by Marcia Smith.

Hubble Space Telescope

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