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The National Aeronautics and Space Administration's FY2004 Budget Request: Description, Analysis, and Issues for Congress

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The National Aeronautics and Space Administration's FY2004 Budget Request: Description, Analysis, and Issues for Congress

Summary

NASA's budget request for FY2004 is $15.469 billion, approximately a 1% increase over its FY2003 appropriations level of $15.339 billion, or a 3.1% increase over its FY2003 request of $15.0 billion. The House-passed version of the FY2004 VA-HUD-IA appropriations bill (H.R. 2861) adds $71 million to the request. The Senate Appropriations Committee recommended a $130 million cut (S. 1584).

Debate over NASA's FY2004 budget is taking place against the backdrop of the space shuttle *Columbia* tragedy, which could have significant impacts on NASA's budget. There are immediate questions of how funding will change for the shuttle program itself, the space station program (which uses the shuttle to take people and cargo to and from the station), the Office of Biological and Physical Research (which funds research on the shuttle and station), and plans to develop an Orbital Space Plane. One aspect of that discussion is whether to continue permanent occupancy of the space station if the shuttle is grounded for a long period of time. For the longer term, Congress is expected to address more fundamentally whether human space flight is worth its risks and costs, and what should be the balance between human and robotic space flight activities.

The agency's FY2004 budget was formulated prior to the *Columbia* tragedy, but initial deliberations, at least, will focus on what is presented in that budget estimate and two associated documents (a strategic plan, and a FY2002 performance and accountability report) that herald NASA's adoption of performance based budgeting. Care should be taken in using the FY2004 budget materials. First, they are presented in "full cost accounting" where all program costs, including personnel and facilities, are included in individual program budgets instead of separately. It may appear that programs are receiving funding increases; yet a higher figure in FY2004 may be the result of full cost accounting, not program content, changes. Second, NASA revised the organizational structure of its budget, making it difficult in some cases to trace program budgets. Apart from *Columbia*, other major NASA budget issues include:

- **International Space Station Program**: Assuming construction and operation of ISS continues, will the Bush Administration commit to building it so that it can accommodate seven crew members, as originally planned, instead of three?
- **Project Prometheus**: Can NASA afford this multi-billion dollar program to build a nuclear powered, nuclear propelled spacecraft, and what are the policy implications of expanding the use of nuclear power in space?
- **Aeronautics**: Is NASA investing sufficiently in aeronautics R&D?
- **Technology Transfer**: Should Congress approve NASA's decision to terminate several of its technology transfer activities?

This report will be updated as events warrant. An abbreviated version is available as CRS Report RS21430.

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Preface

Congress is debating the $15.469 billion FY2004 budget request of the National Aeronautics and Space Administration (NASA). This report discusses the major issues, particularly the potential ramifications of the February 2003 space shuttle *Columbia* accident. Several other CRS reports are available on NASA-related topics, and are referenced herein. An abbreviated version of this report is available as CRS Report RS21430.

Throughout this report, FY2003 funding levels are based on amounts contained in the FY2003 Consolidated Appropriations Act (P.L. 108-7), which included a 0.65% rescission for all NASA activities except the space shuttle. FY2004 request figures are from NASA's FY2004 budget estimate, available at [http://www.nasa.gov/about/budget/]. Program descriptions are condensed from material provided by NASA in that or previous budget estimates.

This report continues the series of annual CRS analyses of NASA budget requests initiated by former CRS Specialist David Radzanowski, and continued by former CRS Senior Specialist Richard Rowberg. It draws upon some of the content of the earlier reports.

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 45 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; **Dryden Flight Research Center**, Edwards, CA; **Glenn Research Center**, Cleveland, OH; **Goddard Space Flight Center**, Greenbelt, MD; **Johnson Space Center**, Houston, TX; **Kennedy Space Center**, Cape Canaveral, FL: **Langley Research Center**, Hampton, VA; **Marshall Space Flight Center**, Huntsville, AL; and **Stennis Space Center**, near Slidell, MS. The **Jet Propulsion Laboratory**, Pasadena, CA (often counted as a 10th NASA center), is a federally funded research and development center operated for NASA by the California Institute of Technology. Goddard Space Flight Center 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). Ames Research Center manages Moffett Federal Airfield, Mountain View, CA. Johnson Space Center manages NASA activities at the White Sands Test Facility, White Sands, NM. Web links to all these can be found at [http://www.nasa.gov/nasaorgs/index.html].[1]

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].

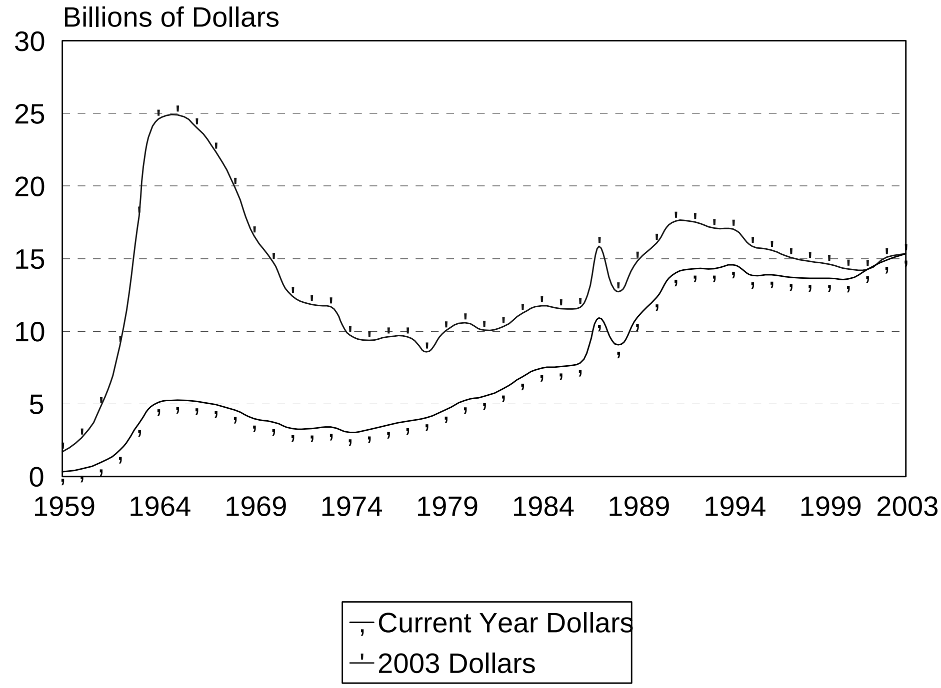
NASA is headed by an Administrator. The current Administrator is Mr. Sean O'Keefe, who was confirmed by the Senate on December 20, 2001. Immediately prior to his appointment, he was deputy director of the Office of Management and Budget (OMB). Previously, he was staff director for the Senate Appropriations Subcommittee on Defense, the Comptroller of DOD, Secretary of the Navy, and a professor at Pennsylvania State University and Syracuse University. Mr. O'Keefe is the 10th NASA Administrator. His predecessor was Mr. Daniel Goldin, who held the position for almost 10 years.

NASA's Historical Budget

Since its creation, 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 (unadjusted for inflation) and in 2003 dollars. 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. Since 2000, it has been rising gradually to its FY2003 level of $15.339 billion (current year dollars). For information on NASA's FY2003 budget, see CRS Report RL31347, *The National Aeronautics and Space Administration's FY2003 Budget Request: Description, Analysis, and Issues for Congress.*

[1] CRS Report RL30577, *National Aeronautics and Space Administration: History and Organization*, by Erin Hatch, provides further information on NASA's origin and structure.

Figure 1: NASA Funding FY1959-2003



Source: Data on NASA budget authority in current dollars through 2000 are from the Aeronautics and Space Report of the President: FY 2000; for 2001-2002 are from the Historical Tables of the Budget of the U.S. Government, FY2004; for 2003 are from P.L. 108-7, adjusted for the 0.65% across-the board rescission for all NASA activities except the space shuttle. Constant dollars (adjusted for inflation to reflect 2003 dollars) were calculated by CRS using the GDP (chained) price index.

Table 1: NASA Budget Authority, Past Ten Years

(in millions of dollars)

Fiscal Year	**Current Dollars** (unadjusted for inflation)	**2003 Dollars**
1994	14,570	17,037
1995	13,854	15,856
1996	13,884	15,579
1997	13,709	15,088
1998	13,648	14,812
1999	13,653	14,623
2000	13,601	14,291
2001	14,257	14,620
2002	14,893	15,091
2003	15,339	15,339

Source: Current dollars for 1994-2000 are from the Aeronautics and Space Report of the President: FY 2000; for 2001-2002 are from the Historical Tables of the Budget of the U.S. Government, FY2004; for 2003 are from P.L. 108-7, adjusted for the 0.65% across-the board rescission for all NASA activities except the space shuttle. Constant dollars (adjusted for inflation to reflect 2003 dollars) were calculated by CRS using the GDP (chained) price index.

Key Issues in the FY2004 Budget Request

This report examines issues that Congress may consider as it reviews NASA's activities in the context of the FY2004 budget request. Key questions are listed below. More details can be found in the subsequent sections of the report.

- What will be the impact of the space shuttle *Columbia* accident on NASA's budget, and on the space program as a whole? Should the United States remain committed to human exploration of space, or should the agency shift more resources into robotic exploration, which avoids the risks to human life?

- While many consider the likelihood of the United States abandoning human exploration to be extremely small, what would be the future of the International Space Station program if it did? ISS is a cooperative program among the United States, Europe, Canada, Japan, and Russia. Would the other countries assume ownership and operation of the facility? The United States has spent more than $30 billion on building a space station since 1985. How would the American public react to a decision to walk away from the project at this point?

- Assuming the United States continues its participation in the space station program, will the Bush Administration commit to building it as agreed in 1993 so that it can accommodate a crew of seven? Or is the Administration still willing to commit only to building the truncated version it announced in 2001, which accommodates a crew of three? The number of crew members affects how much scientific research can be conducted there, and the U.S. decision to build a truncated version is a contentious issue with U.S. scientists who plan to use the facility and with the other partners in the program.

- Assuming the United States continues its participation in the space station program, should NASA accelerate development of the Orbital Space Plane (OSP) to take crews to and from the space station now that there are only three space shuttle orbiters in the fleet? The OSP concept is early in its formulation stage. How much could its schedule be accelerated if desired? How much would it cost? Does NASA need to build a vehicle that can both take crews to the space station as well as return them in an emergency, or should the agency focus on a simpler, less expensive vehicle that performs only the crew return ("lifeboat") function, which is all that is required under the international agreements that govern the program?

- Can NASA afford Project Prometheus, a new multibillion initiative in the Office of Space Science to build a spacecraft to study three moons of Jupiter? It would use nuclear power and propulsion systems whose development was approved in the FY2003 budget. NASA's preliminary cost estimate is $3 billion over the next 5 years (FY2004-2008), or $8-9 billion through 2012 when the spacecraft would be launched. Additionally, will the public accept an expansion of the use of nuclear power in space?

- What are the implications of NASA's latest reformulation of its earth science program on the long-term study of global climate change? NASA's new plan is to rely on instruments aboard weather satellites operated by two other agencies (the Department of Defense and the National Oceanic and Atmospheric Administration), instead of building additional satellites in its Earth Observation Satellite series, to fulfill its commitment to provide a 15-year set of climate data. Budget constraints already are arising in the DOD/NOAA program. What guarantees are there that DOD and NOAA will include the instruments needed for the scientific community, since their primary responsibility is short term weather forecasting, not long term scientific research?

- How will the Office of Biological and Physical Research recoup from the space shuttle *Columbia* accident in terms of the science experiments it sponsored aboard *Columbia*, and the research it is hoping to conduct on the International Space Station? The research program for the space station was reformulated last year in the wake of funding cuts and the possibility that space station crews would be limited to three, instead of seven, astronauts, thereby reducing the amount of time available to conduct research. While the shuttle is grounded, space station crews are being reduced to two. How will that affect the scientific research that can be conducted there in the short term?

- Is NASA investing sufficiently in aeronautics research and development (R&D)? NASA funding for aeronautics R&D is down by about half from its FY1998 peak and is projected to decline further in coming years. Aeronautics R&D 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.

- What are the implications of NASA's decision to terminate many of its technology transfer activities? NASA plans to close its six Regional Technology Transfer Centers (RTTCs) in Los Angeles, CA; College Station, TX; Cleveland, OH; Newport News, VA; Westborough, MA; and Atlanta, GA. It also will discontinue its annual "Spinoff" books that provide examples of successfully commercialized NASA technology. In the wake of the space shuttle *Columbia* accident, questions are again arising as to what value taxpayers receive from their investment in NASA. While some are comfortable with intangible benefits such as gaining knowledge of the universe or satisfying a desire to explore, others prefer tangible benefits, which these technology transfer activities emphasize.

Overview of NASA's FY2004 Budget Request

NASA's FY2004 budget request is $15.469 billion (see Table 2), a 3.1% increase over the agency's FY2003 request, or an approximately 1% increase over its FY2003 appropriation of $15.339 billion.[2] Congressional action is summarized in the **Overview of Congressional Action on NASA's FY2004 Budget Request** section below, and provided in more detail in subsequent sections of this report.

As described below, care must be taken when reviewing NASA's FY2004 budget request figures because of two significant changes in the agency's budget structure: the shift to full cost accounting, and new appropriations accounts.

Full Cost Accounting

Users of NASA's FY2004 budget material should bear in mind that it reflects NASA's shift to "full cost accounting." In full cost accounting, funding for each program (such as the Mars program) includes the costs for personnel and facilities. Previously, those costs were accounted for separately. NASA began its Full Cost Initiative in 1995, and asserts that today it is a key component in implementing the President's Management Agenda (discussed below). NASA began the transition to full cost accounting in its FY2002 budget by assigning these costs to each enterprise (e.g. the Space Science Enterprise). This year, NASA is taking the further step of assigning the costs directly to each program.

The intent of full cost accounting is to show more accurately a program's total cost. A consequence of this approach during the transition period, however, is to make it appear that funding for many programs has increased substantially. Looking quickly at NASA's FY2004 request, one might conclude, for example, that funding for the space shuttle increased more than $700 million from a request of $3.2 billion in FY2003, to a request of $3.9 billion FY2004. A closer look shows, however, that the FY2004 request is only $182 million higher than the FY2003 request. The remainder of the difference is due to inclusion of personnel and facilities costs that were included in the "Investments and Support" line in NASA's Human Space Flight budget last year. Full cost accounting is discussed in more depth below (see **Vision, Mission, and Performance Based Budgeting**).

New Appropriations Accounts

A second significant change in FY2004 is different appropriations accounts. NASA has two accounts.[3] Last year, the two accounts were Human Space Flight

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[2] NASA's FY2003 appropriations are included in the FY2003 Consolidated Appropriations Act (P.L. 108-7). That Act includes a 0.65% rescission from all activities covered by the Act, with a few exceptions. One of those exceptions is NASA's space shuttle program in the aftermath of the February 2003 space shuttle *Columbia* tragedy. The $15.339 billion figure is adjusted for the rescission.

[3] NASA refers to its "two account" budget structure. That terminology does not include
(continued...)

(HSF), and Science, Aeronautics, and Technology (SAT). The HSF account included funding for: space station; space shuttle; payload and Expendable Launch Vehicle support; space communications and data support; and safety, mission assurance, and engineering. SAT funding included: space science, earth science, biological and physical research, aerospace technology, and academic programs. This year, NASA revamped the budget structure to better reflect its priorities and activities. NASA is seeking to demonstrate that its mission is "Science, Aeronautics, and Exploration," and that mission is supported by "Space Flight Capabilities" such as a space station, space transportation (the space shuttle and expendable launch vehicles), space communications systems, and investing in new technologies. Everything that NASA does is not a perfect fit for the new structure. For example, NASA's investment in nuclear propulsion technologies is included in the Space Science request, not in Crosscutting Technologies with NASA's other investments in space transportation technologies.

Comparing FY2003 and FY2004

Thus, care should be exercised in making comparisons between FY2003 and FY2004. Because of the change in the budget structure and the shift to full cost accounting in FY2004, CRS cannot create a meaningful table comparing the FY2003 request, FY2003 appropriations, and the FY2004 request, as would normally be provided in this report. Instead, two tables are presented. Table 2 shows the original FY2003 request (without full cost accounting), the FY2003 request with full cost accounting, and the FY2004 request in full cost accounting, all provided by NASA. These are followed by columns showing congressional action. **Special attention should be paid to the column headings, which explain what the figures represent**. Table 3 shows what Congress appropriated for NASA for FY2003 using the FY2003 appropriations categories, with no full cost accounting.

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[3] (...continued)
funding for the Inspector General, however, which is a separate (third) account.

Table 2: NASA's FY2004 Budget Request and Congressional Action

(In millions of dollars)

Category	FY2003 Request (Nov. 2002) *Not in full cost accounting*	FY2003 *Request* Expressed in Full Cost Accounting	FY2004 Request Expressed in Full Cost Accounting	House-passed VA-HUD-IA appro-priations	Senate-reported VA-HUD-IA appro-priations
Science, Aeronautics & Exploration	**7,015**	**7,101**	**7,661**	**7,708****	**7,731****
Space Science	3,414	3,468	4,007		
Earth Science	1,628	1,610	1,552		
Biological & Physical Research	842	913	973		
Aeronautics	986	949	959		
Education	144	160	170		
Space Flight Capabilities	**7,960**	**7,875**	**7,782**	**7,806**	**7,582**
Space Flight	6,131	6,107	6,110	6,110	5,910
Space Station*	(1,492)*	(1,851)*	(1,707)*	(1,707)	(1,507)
Space Shuttle	(3,208)	(3,786)	(3,968)	(3,968)	(3,968)
Other	(1,431)	(471)	(434)	(434)	(434)
Crosscutting Technologies	1,829	1,768	1,673	1,697	1,673
Space Launch Initiative	(879)	(1,150)	(1,065)	(1,065)	(1,065)
Other	(950)	(617)	(607)	(631)	(607)
Inspector General	**25**	**25**	**26**	**26**	**26**
Total	**15,000**	**15,000**	**15,469**	**15,540**	**15,339**

Source: NASA FY2003 and FY2004 budget documents, H.R. 2861 (H.Rept. 108-235), and S. 1584 (S.Rept. 108-143). Column totals may not add due to rounding. NASA submitted an amended FY2003 budget request in November 2002, which NASA used in developing the numbers in the second and third columns of this table. **The figures in the third (shaded) column adjust the FY2003 numbers as though they had been prepared in full cost accounting. They are for comparison purposes only and do not reflect actual funding increases or decreases.**

*Does not include funding for space station research, embedded in the Biological and Physical Research line. For FY2004, that amount is $578 million, making the total FY2004 space station request $2,285 million.

**It is not possible in all cases to determine from the committee reports what changes were made to which SAE subaccounts, so only the total funding for the SAE account is shown here.

Table 3. NASA's FY2003 Request v. FY2003 Appropriations
(in $ millions)

Funding Category	FY2003 Request	FY2003 Appropriations
Human Space Flight	**6,130.9**	**6,058.6**
International Space Station	1,492.1*	1,462.4*
Space Shuttle	3,208.0	3,252.8†
Payload and ELV Support	87.5	84.4
Investments and Support	1,178.2	1,094.9†
Space Comm. & Data Systems	117.5	115.3
Safety, Mission Assur., Engineering	47.6	48.8
Science, Aeronautics, and Technology	**8,844.5**	**9,254.9**
Space Science	3,414.3	3,529.2
Biological. & Physical Research	842.3*	896.0*
Earth Science	1,628.4	1,697.4
Aero-Space Technology	2,815.8	2,933.6
Academic Programs	143.7	198.6
Inspector General	**24.6**	**25.4**
TOTAL	**15,000.0**	**15,338.9**

Sources: NASA FY2003 budget estimate and initial FY2003 operating plan. Columns may not add due to rounding.
*Total funding for the space station is the sum of the funding under Human Space Flight plus a portion of the funding in Biological and Physical Research. The total FY2003 request for the space station was $1.839 billion; Congress approved that amount and added $8 million for ISS plant and animal habitats. With the rescission and adjustments NASA made in its FY2003 initial operating plan, the amount available for the space station in FY2003 is $1.810 billion.
† Space shuttle is exempt from the rescission (both the amount in the" space shuttle" line, and personnel and other related costs in the "investments and support" line). Congress added $50 million for the investigation and remedial actions stemming from the space shuttle Columbia accident.

NASA's Six Enterprises and 18 "Themes"

In the FY2004 budget estimate, NASA divides its activities into six "enterprises." Five of them—the Aerospace Technology Enterprise, the Biological and Physical Research Enterprise, the Earth Science Enterprise, the Space Flight Enterprise (formerly the Human Exploration and Development of Space Enterprise), and the Space Science Enterprise—correspond to NASA's five major program offices: the Office of Aerospace Technology (OAT), the Office of Biological and Physical Research (OBPR), the Office of Earth Science (OES), the Office of Space Flight (OSF), and the Office of Space Science (OSS). The sixth enterprise, Education, cuts across the other five enterprises.

In the FY2004 budget request, NASA also introduced 18 "themes" it has decided to use to organize the agency's activities. According to NASA, theme managers will have responsibility and accountability for the programs within those themes. In some parts of NASA, it is difficult to ascertain the difference between a "theme" manager and a division director or other official within an enterprise. These distinctions may become clearer with experience. The 18 themes are:

Table 4: NASA's 18 Themes

Space Science	1. Solar System Exploration
	2. Mars Exploration
	3. Astronomical Search for Origins
	4. Structure & Evolution of the Universe
	5. Sun-Earth Connections
Earth Science	6. Earth System Science
	7. Earth Science Applications
Biological & Physical Research	8. Biological Sciences Research
	9. Physical Sciences Research
	10. Research Partnership and Flight Support
Aerospace Technology	11. Aeronautics Technology
	12. Space Launch Initiative
	13. Mission and Science Measurement Technology
	14. Innovative Technology Transfer Partnerships
Education	15. Education
Space Flight	16. Space Station
	17. Space Shuttle
	18. Space Flight Support

Source: NASA's FY2004 Budget Estimate.
Prepared by CRS.

New Initiatives in FY2004

NASA lists nine new initiatives in its FY2004 request. Traditionally, the term "new initiative" was used to indicate initiation of a new program or project. In the FY2004 request, however, NASA also uses it to represent new emphasis on an existing program or project. Thus, not all of the nine initiatives are new programs or projects. They are described under the appropriate enterprise later in this report. The nine initiatives are:

Table 5: NASA's Nine New Initiatives in FY2004

Initiative	FY2004 Request ($ millions)	Projected Funding FY2004-2008 ($ millions)
To Understand and Protect Our Home Planet		
Climate Change Research Acceleration	26	72
Aviation Security	21	196
National Airspace System Transition Augmentation	27	100
Quiet Aircraft Technology Acceleration	15	100
To Explore the Universe and Search for Life		
Project Prometheus*	*279	*3,000
Optical Communications	31	233
Beyond Einstein Initiative	59	765
Human Research Initiative	39	347
To Inspire the Next Generation of Explorers		
Education Initiative	26	130

Source: NASA's FY2004 Budget Estimate, p. AS-10, AS-11, and SAE 2-21.
*Project Prometheus combines the Nuclear Systems Initiative begun in FY2003 to develop space nuclear power and propulsion systems, with new plans to build a spacecraft, the Jupiter Icy Moons Orbiter (JIMO), to use those systems. However, the NASA chart (p. AS-10) on which this table is based shows a request of $93 million for Project Prometheus in FY2004, and a 5-year runout of $2.07 billion, which are the costs only for JIMO, not for the nuclear power and propulsion systems. On p. SAE 2-21 of its budget estimate, NASA shows the total FY2004 request for Project Prometheus as $279.2 million. On p. AS-11, NASA identifies the 5-year runout for Project Prometheus as $3 billion. Hence, those are the figures used in this table.

Overview of Congressional Action on NASA's FY2004 Budget Request

This section provides an overview of actions taken by Congress on NASA's FY2004 budget request. More detail is provided in subsequent sections. Table 2 (above) shows the changes compared with the request.

House Action

As passed by the House on July 25, the FY2004 VA-HUD-IA appropriations bill (H.R. 2861, H.Rept. 108-235) includes a $71 million net increase above the $15.469 billion request. The net increase comprises $96 million in cuts and $167 million in additions.

The House took no action on NASA's space shuttle, International Space Station, Orbital Space Plane, or Next Generation Launch Technology programs pending release of the report of the *Columbia* Accident Investigation Board. The major programmatic changes are the addition of $24 million to continue commercial program initiatives proposed for termination (see **Innovative Technology Transfer Partnerships** below), several additions for aeronautics (see **Aeronautics Technology**), and cuts to four space and earth science programs—the New Frontiers program, which involves sending a probe to Pluto, was cut $55 million; the James Webb Space Telescope was cut $20 million; the Space Interferometry Mission was cut $8.15 million, and Earth Science Applications was cut $13 million. The first three are discussed under **Space Science**; the last is discussed under **Earth Science**.

Senate Action

The Senate Appropriations Committee reported its version of the FY2004 VA-HUD-IA appropriations bill on September 5 (S.Rept. 108-143). The committee recommended a net cut of $130 million from NASA's request, comprising a reduction of $200 million for the space station program, and $70 million in net increases for congressionally directed spending in the Science, Aeronautics, and Exploration (SAE) account. (The committee's report specifies that the SAE account is to be funded at $7.730 billion, an increase of $69.6 million over the request. The detailed list of changes within the various subaccounts total $174 million in increases, and $46 million in cuts, yielding a net increase of $128 million rather than the $69.6 million, however. The report does not specify where the additional cuts should be made to reduce the overall level of the SAE account to its recommended level.) The specified cuts are $20 million from the Jupiter Icy Moons Orbiter, part of Project Prometheus (see **Space Science**), and $15 million from Earth Science Applications and $11 million from the Global Change Climate Research Initiative (see **Earth Science**). Among the major additions are $50 million for aeronautics research (see **Aeronautics**), and $11 million for EOS Follow-on mission planning and $25 million for EOSDIS (see **Earth Science**).

Agency-Wide Issues

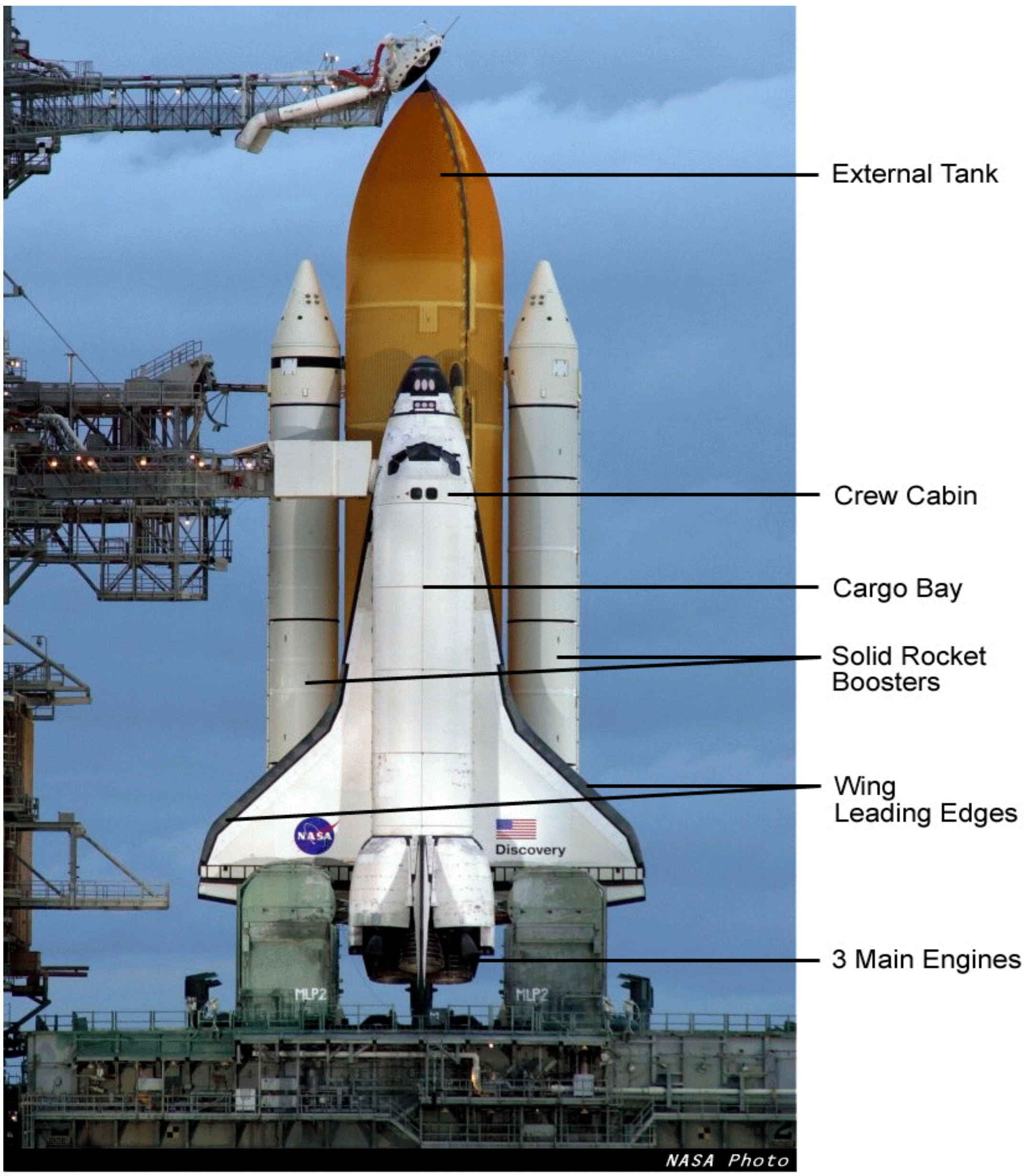
Space Shuttle *Columbia* Accident

On February 1, 2003, the space shuttle *Columbia* broke apart as it returned to Earth following a 16-day scientific mission in Earth orbit. All seven astronauts—six Americans and one Israeli—were killed. The shuttle fleet is grounded. The *Columbia* Accident Investigation Board (CAIB), headed by retired Admiral Harold Gehman, released the results of its investigation on August 26, 2003, attributing the accident to technical and organizational failures. CRS Report RS21408 provides more information about the *Columbia* tragedy; CRS Report RS21606 provides a synopsis of the Board's findings and recommendations. The full CAIB report is available at [http://www.caib.us]. NASA officials use March/April 2004 as a "preliminary planning window" for returning the shuttle to flight. They stress, however, that they cannot fix a date for return to flight until they have a better understanding of what must be done, and how to do it, in response the Board's 29 recommendations, of which 15 must be accomplished before return to flight. For more on the shuttle program, see "Space Shuttle" under **Space Flight Capabilities** below.

What impact the *Columbia* tragedy will have on NASA, and the space program as whole, is unclear. The resumption of shuttle launches is a critical component of answering questions such as what strategy to follow in staffing the International Space Station (ISS). 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.

In the wake of the *Columbia* accident, some are questioning whether human space flight is worth its risks and costs. Following the Apollo 204 and *Challenger* tragedies, the country ultimately rallied behind NASA, and human space flight resumed after technical and managerial issues were resolved. Many expect the public will respond similarly this time. Assuming that it does, and NASA continues its human space flight program, some near-term decisions are needed.



The space shuttle, or Space Transportation System (STS), consists of an airplane-like orbiter, two Solid Rocket Boosters on each side, and a large, cylindrical External Tank that holds fuel for the orbiter's engines.

Should Crews Remain Aboard the Space Station While the Shuttle Is Grounded? Chief among the issues is whether to keep crews aboard the International Space Station (ISS) while the shuttle is grounded. (See CRS Issue Brief IB93017 for more on ISS). The space station is being built as a partnership among the United States, Russia, Canada, Japan, and Europe. Construction began in 1998, and "Expedition" crews, rotating on 4-6 month shifts, have continuously occupied ISS since November 2000.

In late February, NASA and its partners agreed upon an approach to staffing the space station in 2003 without the space shuttle. The usual three-person crew size was reduced to two in order to reduce resupply requirements. The ISS program will rely on Russian Soyuz spacecraft to rotate the crews, and another Russian spacecraft, Progress, to resupply the space station with food, water, fuel, and other consumables. The Russians have three decades of experience in operating space stations using only Soyuz and Progress spacecraft. Russia provides Soyuz and Progress spacecraft for the ISS program already, but additional Progress spacecraft will be required without the shuttle, raising funding issues (discussed below).

The "Expedition 7" crew—one American and one Russian—is now aboard ISS. They are scheduled to be replaced by the Expedition 8 crew in October 2003. They may return to Earth at any time, however, using the Soyuz spacecraft that took them to ISS. Soyuzes are used as "lifeboats" for the space station, and one is always attached so the crew can evacuate in an emergency. Each Soyuz can only remain in orbit for 6 months, so they are routinely replaced at 6-month intervals.

The ISS can be operated using Soyuz and Progress indefinitely, if sufficient funds are available to build them. However, if the shuttle is grounded for an extended period of time, questions may arise as to whether there is sufficient reason for a crew to be there. The shuttle is needed to bring additional segments of the space station into orbit to continue construction, and also to bring the scientific experiments that form the research program. Thus, there may be little for the crew to accomplish other than maintaining and operating the station. Whether that is sufficient reason to keep crews in orbit, with the attendant risks of space travel, may be questioned. One concern, though, is what would happen if the space station suffered a malfunction that could only be repaired by an on-orbit crew. If no one was aboard, the facility, which already has cost U.S. taxpayers $30 billion, could be imperiled.

Who Will Pay For Additional Cargo Flights to the Space Station? The space shuttle has a much greater cargo capacity than the Russian Progress spacecraft, so even just to resupply a two-person crew, the number of annual Progress flights must be increased from the current rate of three or four per year. Russian space agency officials have indicated for quite some time, however, that they are having difficulty funding the Soyuz and Progress spacecraft to which they are already committed. They want the other partners in the program to provide $100 million for accelerating the production of two Progress spacecraft needed in the near term. Under the Iran Nonproliferation Act (INA, P.L. 106-178), however, NASA is not allowed to transfer money to Russia in connection with the space station program unless the President certifies that Russia is not proliferating certain technologies to Iran (see CRS Issue Brief IB93017). Representative Lampson has introduced H.R.

1001 to amend the INA to allow payments to Russia for the space station any time the U.S. space shuttle is grounded. NASA Administrator O'Keefe told the House Science Committee on February 27, 2003 that no changes to the INA are needed at this time, and he had not asked the White House for a waiver from the INA requirements.[4] At the moment, the Russian government has agreed to accelerate payments to the Russian Space Agency that ordinarily would not have been provided until later in the year. Russian space officials remain publicly concerned about the availability of funds in the future. The House Science Committee's Subcommittee on Space and Aeronautics held a heading on U.S.-Russian space cooperation on June 11, 2003 where these issues were explored.

Should the Orbital Space Plane Program be Accelerated? Another near-term decision is whether to accelerate development of NASA's Orbital Space Plane (OSP), a program announced in November 2002, or build another spacecraft that would be simpler and less expensive, but potentially less versatile.

The OSP is a Crew *Transfer* Vehicle (CTV). It is the successor to NASA's plans to build a Crew *Return* Vehicle (CRV). A Crew Transfer Vehicle can take crews to and from the space station; a Crew Return Vehicle can only bring them back to Earth. The purpose of a Crew Return Vehicle is to act as a lifeboat in the event of a life-threatening emergency on the space station. Under the international agreements that govern the space station program, the United States is obligated to provide a Crew Return Vehicle to accommodate four people. Once available, it would allow the space station crew size to grow (space station crew size is a controversial issue that is discussed later in this report under "Space Station," and in CRS Issue Brief IB93017). A Crew Transfer Vehicle could fulfill that mission, as well as complement the space shuttle's ability to take crews to the space station. The evolution of the CRV into a CTV is discussed in more detail later in this report (see Crosscutting Technologies), but essentially NASA is now embarked upon a course to build a CTV instead of a CRV. A CTV is expected to be more expensive and take longer to develop than a CRV. From the standpoint of recovering from the *Columbia* accident, one question is whether OSP should be accelerated now that there are only three space shuttle orbiters. NASA notified its OSP contractors in July 2003 that it wants to accelerate the program by two years. *Space News* reported on September 1, 2003 that accelerating the OSP program by two years could significantly increase its cost. According to that publication, the cost through FY2009 could be $14 billion, compared with the $3.7 billion NASA included in its 5-year (FY2004-2008) budget estimate.

What Are the Impacts on the FY2004 Budget? How much it will cost to return the shuttle to flight status is not yet known. What is known is that the grounding of the shuttle will impact the schedule for construction of the station, and almost certainly will increase its costs. It could alter the funding profile for the Orbital Space Plane. It also is likely to affect funding for the Office of Biological and Physical Research (OBPR), which uses the space shuttle and space station to conduct some of its research activities. OBPR was the sponsor of many of the experiments

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[4] Mr. O'Keefe was responding to a question from Representative Lampson. Transcript of hearing provided by Federal Document Clearing House.

on *Columbia*'s ill-fated STS-107 mission. Although some of the scientific data from that mission was transmitted to ground-based scientists while the shuttle was in orbit, much was lost with *Columbia.* Decisions will be needed on whether any of that research needs to be redone and at what cost. Thus, the impact on the FY2004 NASA budget and future budgets could be significant.

Is Human Space Flight Worth the Risks and Costs? While it seems unlikely, it is nevertheless possible that the public and policy makers could choose to discontinue or sharply limit human space flight in response to the *Columbia* accident. The debate over the value of human space flight has been waged since the earliest days of the space program.

Human exploration of space appeals to what many believe is an innate desire to push the frontiers of human experience. Supporters of human space flight view the space station as the next step in America's—and humanity's—inexorable desire to explore new worlds. As a visible symbol of America's technological prowess, human spaceflight is often perceived as a centerpiece of an image of American preeminence.

This somewhat romantic view is in stark contrast to those who view human exploration of space as, at best, a waste of money, and at worst, an unnecessary exposure of humans to the hazards of space travel. These observers argue that there is much yet to explore here on Earth, and robotic spacecraft should be used to explore the heavens for safety and cost-effectiveness reasons. They see the Apollo, space shuttle, and space station programs as successive drains on resources that could be better used for robotic space activities, or non-space related activities.

Since 1959, when the first American astronauts were selected, the majority of the American public has supported NASA's human space flight program, within limits. (There has not been sufficient support to mount a human mission to Mars, for example, a goal of some space enthusiasts.) The *Columbia* tragedy is the latest test to determine if the public remains committed to the goal of human exploration of space or if it would prefer a shift in emphasis to robotic missions that do not risk human life.

One factor in such a decision would be the fate of the International Space Station if the United States terminates its human exploration program. The United States is the leader of the multinational space station program and, since 1984 (FY1985), over $30 billion U.S. tax dollars have been spent on it (not including the costs of the associated shuttle flights). Presumably, if the United States chose not to use the facility, the other partners would continue to do so using the Russian Soyuz and Progress spacecraft. Public reaction to the concept of turning the space station over to others, when so much money has been spent already, might be a significant influence on the decision whether to continue launching humans into space.

Press reports and discussion at a September 10, 2003 hearing before the House Science Committee indicate that the Bush Administration may articulate a new vision for the space program in coming months. NASA Administrator O'Keefe confirmed that an interagency process is underway to assess the space program, although details were not provided. Separately, Representative Lampson introduced H.R. 3057 on September 10, the Space Exploration Act, to set goals for the space program.

Vision, Mission, and Performance Based Budgeting

NASA's FY2004 budget reflects the agency's moves to implement the President's Management Agenda,[5] to sculpt the agency to match Administrator O'Keefe's vision, and to move to "performance based budgeting." The budget documents include not only the budget estimate, called the "FY2004 Integrated Planning and Budget Document," but NASA's new Strategic Plan and a FY2002 Performance and Accountability Report. Administrator O'Keefe emphasizes that releasing the Strategic Plan and budget together —

> represents our new commitment to the integration of budget and performance reporting. In this way, we will ensure that strategic priorities are aligned with and influence budget priorities. Our new Integrated Budget and Performance Document...expands on the goals and objectives presented here and identifies the specific long-term and annual performance measures for which we will be held accountable.[6]

By using these tools and its new approach, NASA asserts that it has developed a FY2004 budget estimate that is "responsible, credible, and compelling." In its report on the FY2004 VA-HUD-IA appropriations bill (H.Rept. 108-235), the House Appropriations Committee applauded NASA's new full cost initiative, noting that it is consistent with the CFOs Act of 1990, the Government Performance and Results Act, and the National Performance Review.

Mr. O'Keefe developed his vision for the agency soon after his arrival as Administrator in December 2001. In an April 12, 2002 speech at Syracuse University,[7] he expounded on that vision and NASA's mission. NASA's vision and mission statements appear at the beginning of virtually every NASA headquarters document and briefing presentation to underscore the agency's commitment to them.

Vision: To improve life here,
To extend life to there,
To find life beyond.

Mission: To understand and protect our home planet,
To explore the universe and search for life,
To inspire the next generation of explorers,
...as only NASA can.

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[5] [http://www.whitehouse.gov/omb/budintegration/pma_index.html]

[6] NASA 2003 Strategic Plan, p. iii

[7] [http://www.hq.nasa.gov/office/codez/plans.html]

According to Mr. O'Keefe, the phrase "as only NASA can" means that NASA "will pursue activities unique to our Mission—if NASA does not do them, they will not get done—if others are doing them, we should question why NASA is involved."[8]

As NASA formulated its vision and mission and related performance measures, it decided to reorganize its budget structure to emphasize that NASA's mission is science, aeronautics, and exploration, and that mission is supported by capabilities such as a space station, space shuttle, and investing in new technologies. This restructuring led to the new appropriations accounts shown in the FY2004 budget. Mr. O'Keefe commented in February 2003 testimony to the House Science Committee that the new structure "recognize[s] the reality that there is no arbitrary separation between human and science activities..."[9]

At the same time, NASA moved to "full cost accounting" in FY2004, as discussed previously. While the goal of full cost accounting may be laudable, one issue is that funding shown in the FY2004 budget estimate for at least one program—the space station—still does not reflect its total cost. Looking at the FY2004 budget, one could easily conclude that the request for the space station program is $1.707 billion, as shown in the line titled "Space Station" under "Space Flight" in the Space Flight Capabilities account. However, that figure does not include space station research funding, which is held in the Office of Biological and Physical Research. That amount is $578 million in FY2004. Furthermore, some would add the costs for the Orbital Space Plane, which NASA plans to build to take crews to and from the space station. That funding, $550 million in FY2004, is under Crosscutting Technologies. Traditionally NASA has included the costs for space station research, and for a "crew return vehicle," the predecessor of the Orbital Space Plane, in the space station budget. To compare the space station request for FY2004 with previous years, those three figures—$1.707 billion, $578 million, and $550 million—should be added together, yielding a total of $2.835 billion. Yet the budget information from NASA does not make that clear, despite its efforts to illustrate full cost accounting. Some might also add most of the funding for the space shuttle program because the primary job for the space shuttle is taking crews and cargo to the space station. NASA traditionally has not included the cost of the shuttle flights in the space station cost estimates. However, in a full cost accounting environment, it is difficult to argue that shuttle costs should not be included.

Another issue is the complexity of tracing a program's budget over time to determine if it is staying within planned funding parameters. Since personnel and facilities have not been included in program costs until now, determining whether a program is "over budget" is difficult to determine. Again using the space station as an example, Congress imposed a cap of $25 billion on development of the space station, and $17.4 billion on the costs of shuttle flights to assemble it. The General Accounting Office (GAO) concluded in 2002 that it could not determine whether NASA was complying with the cap because NASA could not provide the requisite data (GAO-02-504R). Now, with full cost accounting, it will be even more difficult

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[8] Testimony to the House Science Committee, February 27, 2003, p. 5. Available at [http://www.house.gov/science].

[9] Ibid., p. 6-7.

to determine if the cap is being enforced because the program's cost will grow with the addition of the personnel and facilities costs. This is true for other NASA programs as well.

The Aerospace Safety Advisory Panel (ASAP), an independent group that oversees safety in NASA's programs, pointed out another potential drawback to full cost accounting in its *Annual Report for 2002* (released in March 2003). The ASAP report points out that some agency overhead functions (such as safety), efforts that span several NASA programs (such as orbital debris), and infrastructure that is not dedicated to a specific program, could be inadequately funded in a full cost environment because their costs no longer can be amortized across many activities. Because the costs will be charged to specific programs at direct labor rates, they may become too expensive for program budgets. ASAP found that the shift to full cost accounting "could negatively impact the ability to sustain safe and reliable operation."[10] The panel recommended that the impacts be identified, and that NASA adequately fund programs, personnel, infrastructure and contractor services that are essential to safety.

Human Capital

Human capital is the first of the five government-wide initiatives identified in the President's Management Agenda.[11] Like many other federal agencies, NASA has an aging workforce. At a February 27, 2003 hearing before the House Science Committee, Mr. O'Keefe noted that "today, we have three times as many personnel over 60 years of age as under 30 years of age." He also commented that within the next five years, 25% of the agency's workforce is eligible to retire. "The potential loss of this intellectual capital is particularly significant for this cutting-edge Agency that has skills imbalances."[12]

NASA proposed legislation in 2002 that Mr. O'Keefe explained would give the agency new authorities to recruit and retain a highly skilled workforce. A summary of the proposals was contained in Mr. O'Keefe's testimony to the House Science Committee's Subcommittee on Space and Aeronautics on July 18, 2002.[13] In addition to Mr. O'Keefe, the Comptroller General of the United States, and the General Counsel of the American Federation of Government Employees testified about the pros and cons of such legislation. That legislation was never introduced, but, according to Mr. O'Keefe, some of the changes were enacted as part of the Homeland Security Act.[14]

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[10] [http://www.hq.nasa.gov/office/codeq/asap/index.htm] p. 24-25.

[11] Available at [http://www.whitehouse.gov/omb/budintegration/pma_index.html].

[12] Prepared statement. P. 9. Available at [http://www.house.gov/science].

[13] Available at [http://www.house.gov/science.]

[14] See CRS Report RL31500, *Homeland Security: Human Resources Management*, by Barbara L. Schwemle for general information on civil service changes made by that Act.

In its January 2003 report on Major Management Challenges and Program Risks for NASA, GAO identified strengthening strategic human capital management as one of major four challenges facing NASA.[15] Three bills are pending that address NASA's human capital situation. H.R. 1085 (Boehlert) would provide incentives for hiring and retaining personnel at NASA. It was reported, amended, on August 4, 2003 (H.Rept. 108-244, Part I). It also had been referred to the House Government Reform Committee, from which it was discharged on August 4. H.R. 1836 (Davis) covers workforce issues at NASA, the Department of Defense, and the Securities and Exchange Commission. It was reported, amended, from the House Government Reform Committee on May 19 (H.Rept. 108-116, Part 1). The bill also was referred to, and later discharged from, the Armed Services, Science, and Ways and Means committees. In the Senate, S. 610 (Voinovich) addresses NASA workforce issues. It was reported, amended, from the Senate Governmental Affairs Committee (S.Rept. 108-113). CRS Report RL31991 discusses these bills in more detail.

Detailed FY2004 Budget Issues

This section follows the new format of the NASA budget as shown in the agency's FY2004 budget estimate. Thus, the categories are different from those in previous CRS reports on the NASA budget.

Science, Aeronautics & Exploration

The Science, Aeronautics & Exploration (SAE) account funds the bulk of NASA's research and development (R&D) activities. Included are the Offices of Space Science, Earth Science, Biological and Physical Research, and Education, as well as aeronautics programs, which are part of the Office of Aerospace Technology. 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. Aeronautics R&D 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 FY2004, NASA is requesting $7.661 billion for SAE. See Table 2 for a break-out of how the request is allocated to the different offices within this account. Because of the change in the structure of the FY2004 budget versus the FY2003 appropriations, a comparable number for FY2003 is difficult to determine. In

[15] General Accounting Office. Major Management Challenges and Program Risks: National Aeronautics and Space Administration. January 2003. GAO-03-114. Available at [http://www.gao.gov].

previous years, aeronautics was included in figures for the Office of Aero-Space Technology.[16] Now it is separated from the rest of OAT and placed in the SAE appropriations account rather than the SFC account where the rest of Aerospace Technology activities reside. In the FY2003 Consolidated Appropriations Act (P.L. 108-7), Congress included a number of congressionally directed spending items in the Aero-Space Technology account, and it is not immediately clear which are related to aeronautics versus other activities in that account. Unless NASA shows that division, and adjusts the figures for full cost accounting, a comparison between FY2003 and FY2004 for aeronautics is not possible. However, FY2003 appropriations levels are comparable with the FY2004 request at the aggregate level for the Offices of Space Science, Earth Science, Biological and Physical Research, and Education, and are shown herein.

Space Science. The Office of Space Science (OSS) is responsible for NASA's Space Science Enterprise. OSS has five themes: Solar System Exploration, Mars Exploration, Astronomical Search for Origins, Structure and Evolution of the Universe, and Sun-Earth Connections. 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; and a Mars Exploration program.

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. The technology effort is designed to provide enabling technologies for the next generation of space science missions, crosscutting technology development that can be used on a number of NASA missions, and flight testing of new technologies that can be used on future NASA science missions. The technology program includes a core component directed at broad-based technology development; and a focused component supporting technology development for the astronomical search for origins, the advanced deep space missions, the Sun-Earth connection, and the structure and evolution of the universe programs.

FY2004 Budget Request and Congressional Action. For FY2004, NASA is requesting $4.007 billion for the Office of Space Science, compared with a FY2003 appropriations level of $3.501 billion. The $4.007 billion request is

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[16] In the FY2004 budget, NASA identifies it as the Office of Aerospace Technology instead of Aero-Space Technology, as it had previously,

allocated to each theme as follows: Solar System Exploration, $1.359 billion; Mars Exploration, $570 million; Astronomical Search for Origins, $877 million; Structure and Evolution of the Universe, $432 million; and Sun-Earth Connections, $770 million. The request includes three new initiatives (see Table 6).

Table 6: FY2004 Space Science New Initiatives

(in $ millions)

Initiative	FY04 Request	FY04-08 Estimate	Comments
Project Prometheus	$279	$3,000.0	Combination of Nuclear Systems Initiative, begun in FY03, and new Jupiter Icy Moons Orbiter (JIMO) project. See text for more information.
Optical Communications	$31	$233	To develop communications technologies to allow more data to be sent back to Earth from planetary spacecraft using much higher (laser) frequencies, which have greater bandwidth. NASA plans to demonstrate this technology on a 2009 mission to Mars.
Beyond Einstein	$59	$765	Offers potential to answer three questions unanswered by Albert Einstein's theories—what powered the Big Bang; what happens to space, time, and matter at the edge of a black hole; and what is the mysterious dark energy expanding the universe.

Source: NASA's FY2004 Budget Estimate (see note to Table 5 regarding Project Prometheus). Prepared by CRS.

In the FY2004 VA-HUD-IA appropriations bill, the House cut funding for three programs in the Office of Space Science: $20 million from the James Webb Space Telescope, $8.15 million from the Space Interferometry Mission, and $55 million from New Frontiers (to send a probe to Pluto). The Senate Appropriations Committee recommended a $20 million cut for the Jupiter Icy Moons Orbiter (JIMO), part of Project Prometheus.

Key Issues. Three of the projects being pursued by the Office of Space Science are receiving close attention during the FY2004 budget cycle: Project Prometheus; New Frontiers; and space telescopes, including the James Webb Space Telescope (formerly the Next Generation Space Telescope).

Project Prometheus (Nuclear Systems Initiative and JIMO). NASA is proposing in FY2004 an expansion of the Nuclear Systems Initiative (NSI), which was approved in the FY2003 budget (although Congress cut $19 million of the $125.5 million requested). Through NSI, NASA is developing new radioisotope thermoelectric generators (RTGs) that provide electrical power for spacecraft, and nuclear propulsion to propel spacecraft from Earth orbit to other destinations. In the FY2004 budget, NASA requests permission to build a spacecraft, the Jupiter Icy Moons Orbiter (JIMO), that would make use of the new nuclear systems. JIMO's mission would be to search for evidence of oceans on three moons of Jupiter: Europa, Ganymede, and Callisto. The spacecraft would successively orbit each of the moons for extended data-gathering.

NASA combined NSI and JIMO into Project Prometheus. The cost estimate for Project Prometheus over the next 5 years (FY2004-2008) is $3 billion ($1 billion for NSI, plus $2 billion for JIMO). JIMO would be launched in 2012-2013. The head of NASA's space science program, Dr. Edward Weiler, is quoted in Science magazine (March 28, 2003, p. 1970) as saying the estimate through 2012 is $8-9 billion, but cautions that the cost estimate is very preliminary because the program is so early in its formulation. JIMO is a new request in the FY2004 budget, but Congress included $20 million for it in the FY2003 Consolidated Appropriations Act (P.L. 108-7) on which action was not completed until after NASA's FY2004 budget request was submitted to Congress, and hence the FY2004 request for JIMO was announced.

The project may raise several questions. First is whether the agency can afford such an expensive program at this time. Second is whether the mission is consistent with NASA Administrator O'Keefe's insistence that NASA be a "science-driven" agency. In this case, some may argue that this is a "technology-driven" program, since the intent is to develop nuclear technology, and it appears to some that a science mission was conceived to justify development of the technology, rather than the reverse. There is strong scientific interest in detailed studies of Europa, and Congress approved a Europa mission in the FY2002 budget, capping its cost at $1 billion. In the FY2003 budget request, NASA terminated that mission because it was too expensive. Initiating an even more expensive mission, which was selected without competition (as OSS does with many of its other planetary exploration programs), may spark debate about the choice of mission. At NASA's request, the Space Studies Board (SSB) of the National Research Council developed a "decadal" planetary exploration plan in 2002, which recommended investigations of Jupiter and its moons, but not JIMO specifically.[17] In a June 5, 2003 letter to Dr. Weiler, the SSB said that it did not have sufficient information about the science capabilities of JIMO to determine whether it would meet the Jupiter-system objectives it had presented. Third is public reaction to the use of nuclear power in space. NASA's launches of nuclear-powered spacecraft since the late 1980s have generated protests by some public interest groups concerned about the environment or other issues. Attempts by those groups to prevent the launches have failed, however.

The House approved full funding for Project Prometheus in the FY2004 VA-HUD-IA appropriations bill after defeating (309-114) a Markey amendment that would have shifted $114 million from Project Prometheus into the Superfund cleanup program at the Environmental Protection Agency. The Senate Appropriations Committee recommended a $20 million cut from JIMO because it received the unrequested $20 million in FY2003.

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[17] National Academies. National Research Council. Space Studies Board. New Frontiers in the Solar System: An Integrated Exploration Strategy. Washington, National Academies Press, 2002.

New Frontiers (Pluto Probe). For FY2004, NASA is requesting $130 million for "New Frontiers," a new category of mid-sized planetary exploration projects costing approximately $650 million each. NASA hopes to begin a new project within this category every three years. The first in the series is a probe to explore Pluto, the only planet not yet visited by a NASA spacecraft.

Proposals to send a probe to Pluto have been controversial. NASA selected one Pluto mission, but after the projected cost doubled (from approximately $300 million to about $600 million), notified Congress it wanted to cancel the program. Congress disagreed, and directed NASA to proceed with a Pluto probe. NASA issued a new call for proposals that would cost less than $500 million, and selected the Pluto-Kuiper Belt (PKB) mission for continued study. NASA then determined that it could not afford that project, either, and did not include any funds for a Pluto probe in its FY2003 budget request. A National Research Council study on planetary exploration priorities, prepared at NASA's request and released in 2002, identified a mission to Pluto and the Kuiper Belt (thought to be the home of some comets) as the top priority for the mid-sized class of missions, however. Scientists are anxious to launch a probe to Pluto soon because they want to reach that planet before 2020 when Pluto will move further from the Sun and its atmosphere may collapse. To reach Pluto before then using today's propulsion technology, the probe must be launched in the 2006 time frame so that it can obtain a "gravity-assist" from Jupiter before Jupiter moves out of position. In the FY2003 budget, Congress directed NASA to fund the Pluto probe as the first in the New Frontiers series. NASA is proceeding with the program, and included funding for it in the FY2004 budget request. In the FY2004 VA-HUD-IA appropriations bill, however, the House cut New Frontiers by $55 million. The Senate Appropriations Committee recommended full funding.

Space Telescopes. The James Webb Space Telescope (JWST, formerly known as the Next Generation Space Telescope) is currently expected to be launched in 2011. Its requested full cost budget for FY2004 is $254.6 million. In the FY2004 VA-HUD-IA appropriations bill, the House provided $20 million less than this amount, and also reduced funding for the Space Interferometer Mission (a space telescope system scheduled for launch in 2009) by $8.15 million. The Senate Appropriations Committee recommended an additional $2.5 million for a space telescope-related project at a university, but otherwise made no changes to the requested amount.

In March 2003, it became apparent that JWST was in danger of overrunning its $1.6 billion total budget by $300 million. More than half of that shortfall will be made up by the European Space Agency's commitment to launch the telescope, which will save NASA about $165 million in launch costs. Other savings will result from reducing the diameter of the main mirror from 6.5 meters to 6 meters, making certain other design changes, and cutting contractor costs. The smaller mirror diameter will somewhat reduce the telescope's sensitivity but still falls within NASA's guidelines for the project. A shortfall of $60 to $70 million remains to be resolved. Some experts have suggested that the design changes may increase operating costs once JWST is launched.[18]

JWST is seen by some as a replacement for the Hubble Space Telescope, which was launched in 1990. Others consider it simply as the next in NASA's series of orbiting observatories, but not necessarily a replacement for Hubble. Current plans call for Hubble to be retired at about the same time as JWST is launched, and NASA plans to fund JWST from the "funding wedge" created by the reduction in Hubble funding requirements. NASA estimates that it costs approximately $100 million per year for the periodic Hubble servicing missions by space shuttle crews. This linkage between funding for Hubble and funding for JWST is raising concern. Some supporters of Hubble, who apparently would like to see its mission extended, are concerned about the cost and schedule of JWST. For example, the conference report on the FY2003 Consolidated Appropriations Act (H.Rept. 108-10) notes that current plans call for Hubble servicing missions to end in 2004 to free up funding for JWST. The conferees directed NASA to study the possibility of an additional Hubble servicing mission in 2007.

A related concern is whether there will be a gap between the end of Hubble operations and the beginning of JWST operations. For example, the conference report on the FY2002 VA-HUD-IA Appropriations Act (H.Rept. 107-272) directed NASA to outline a "transition plan to guarantee uninterrupted continuity" between the two missions. Although NASA refers to JWST as a follow-on to Hubble that will build upon Hubble's discoveries, it does not consider JWST a Hubble "replacement" in the sense that data gathering from Hubble must immediately be followed by JWST. NASA points out that JWST will operate at infrared wavelengths, whereas Hubble observes mainly visible light. Consequently, according to NASA, the scientists who will use JWST are a different subset of the astronomy community from those who now use Hubble. Others expect there to be a substantial overlap between the two groups and note that extending Hubble's discoveries to greater distances and earlier stages in the history of the universe is only possible through the type of infrared observations that JWST will make possible. This is because light from objects further away, emitted at earlier times, is shifted in wavelength in the red direction, eventually becoming infrared even if it was originally emitted at visible wavelengths. On the continuity question, some argue that enough Hubble data will have been collected but not yet analyzed to keep astronomers busy for several years, even if no new data were collected during a gap between Hubble and JWST, but others counter that large space-based telescopes now represent such a large share of astronomy capability and funding that an extended gap would have systemic consequences for the astronomy community as a whole.

A related question is what to do with the Hubble when it is retired. NASA does not want the telescope to make an uncontrolled reentry into Earth's atmosphere where pieces might impact populated areas. NASA currently plans to retrieve Hubble using the space shuttle and return it to Earth in 2010. The space shuttle *Columbia* tragedy, and the resultant loss of one of the four space shuttle orbiters, may require a reassessment of those plans. The conference report (H Rept. 108-10) on

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[18] *Space News,* June 3, 2003.

the FY2003 Consolidated Appropriations Act directs NASA to study the means for disposing of Hubble "following the deployment of the Webb Telescope in the 2010 timeframe."

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. Two EOS satellites, Terra and Aqua, are in orbit. NASA expects the third, Aura, to be launched in January 2004. 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.

Over the past two years, NASA has reformulated its Earth Science program to align with President Bush's Climate Change Research Initiative (CCRI) and NASA's new strategic vision and mission. Among the changes is a new focus on factors that may affect climate change other than carbon dioxide (CO_2), such as methane, aerosols, black carbon, and tropospheric ozone. NASA plans to build an Advanced Polarimeter Instrument to study the non-CO_2 factors. 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 (discussed below). OES also is working with industry on a Landsat Data Continuity Mission (LDCM) to provide continuity of data from the Landsat series of satellites. NASA hopes that the private sector, rather than the government, will build the satellite. The government would purchase the data it needed. Landsat 7, built and launched by NASA, is currently in orbit, although a component in its sensor malfunctioned on May 31 and the data currently being returned is not usable. (For more on Landsat, see CRS Issue Brief IB92011.)

FY2004 Budget Request and Congressional Action. NASA is requesting $1.552 billion for Earth Science. The FY2003 appropriation was $1.708 billion. The $1.552 billion is allocated to the two themes as follows: Earth System Science, $1.477 billion; Earth Science Applications, $75 million. The Earth Science Enterprise has one new initiative in FY2004: the Climate Change Research Acceleration (see Table 7).

Table 7: FY2004 Earth Science New Initiative
(in $ millions)

Initiative	FY04 Request	FY04-08 Estimate	Comments
Climate Change Research Acceleration	$26	$72	To build the Advanced Polarimeter Instrument that will accelerate research into non-CO_2 factors affecting global climate change.

Source: NASA FY2004 Budget Estimate.
Prepared by CRS.

In the FY2004 VA-HUD-IA appropriations, the House cut Earth Science Applications by $13 million from its requested level of $75 million. The requested level is an 8.5% decrease from its FY2003 appropriation (in full cost accounting). The Senate Appropriations Committee recommended a cut of $15 million from Earth Science Applications.

Key Issue: NASA's Reformulated Global Climate Change Research Program. NASA's program to acquire systematic data to study global climate change began in the 1980s and has been reformulated many times in response to concerns about cost, and changing political views about the need for such data. In the FY2004 budget, it is reformulated once again to reflect President Bush's approach. Shortly after taking office, President Bush rejected the Kyoto Protocol regarding reduction of CO_2 emissions (see CRS Issue Brief IB89005), and directed the Secretary of Commerce to develop a new Climate Change Research Initiative (CCRI) as the focus of U.S. efforts to study global climate change.

NASA's revised program reflects this new approach with the initiation of the Advanced Polarimeter Instrument, and the termination of plans for follow-on satellites in the EOS series. One issue that arises from the termination of the EOS Follow-on missions is how NASA will fulfill its commitment to the scientific community to provide a 15-year data set of global change observations based on instruments providing comparable data. NASA's response is that it will do so through the National Polar Orbiting Environmental Satellite System (NPOESS), a joint program among the Department of Defense (DOD), the National Oceanic and

Atmospheric Administration (NOAA, in the Department of Commerce), and NASA. DOD and NOAA are developing new weather satellites that meet both their needs, while NASA develops new technologies to achieve that objective.[19]

NASA is developing new sensors for the NPOESS satellites through the NPOESS Preparatory Project (NPP), which NASA describes as a "bridge" between EOS and NPOESS. NPP is in the formulation phase; it has not been approved for development yet. The FY2004 NASA request for NPP is $96 million; the estimate for FY2004-2008 is $289 million. Although maintaining long-term continuity of environmental monitoring and assessment is one of the missions for NPOESS, some scientists may worry that obtaining scientific data for the long term study of climate change may not be a high priority for DOD and NOAA, both of whose primary responsibility in this area is weather forecasting. Budget constraints already are arising in the NPOESS program, and choices may need to be made between sensors for weather forecasting versus scientific research.[20] The concern is that the latter may not be included and data continuity could be lost.

The Senate Appropriations Committee recommended a cut of $11 million from the CCRI program, but an addition of $11 million for mission evaluation studies for EOS follow-on missions. It also recommended an additional $25 million for EOSDIS.

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 and 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 International Space Station, as well as on aircraft and suborbital vehicles, and in ground-based laboratories.

OBPR's budgeting and planning are likely to be significantly affected, at least in the short term, by the space shuttle *Columbia* tragedy. *Columbia*'s 16-day scientific research mission (STS-107) hosted experiments sponsored in large part by OBPR. Other OBPR research is conducted on the International Space Station, whose schedule and utilization is being affected by the accident as well. How OBPR will

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[19] DOD and NOAA currently operate separate polar orbiting weather satellite systems. See [http://www.ipo.noaa.gov/] for more on NPOESS.

[20] NPOESS will succeed NOAA's existing Polar Orbiting Environmental Satellite series. The last satellite in that series, NOAA N Prime, is under construction by Lockheed Martin. A September 2003 accident at the contractor's facility has jeopardized the launch date for that satellite, which fell to the floor as it was being moved. What impact this incident may have on the NPOESS program is not clear.

cope with the aftermath of the *Columbia* accident is the major issue facing the office in FY2004 (see below).

FY2004 Budget Request and Congressional Action. For OBPR, NASA is requesting $972.7 million. For FY2003, Congress appropriated $862.3 million. The $972.7 million request is allocated to the three themes as follows: Biological Sciences Research, $359 million; Physics Sciences Research, $353 million; and Commercial Research and Support, $261 million. OBPR has one new initiative in FY2004: the Human Research Initiative.

Table 8: FY2004 Biological and Physical Research New Initiative

(in $ millions)

Initiative	FY04 Request	FY04-08 Estimate	Comments
Human Research Initiative	$39	$347	To accelerate the acquisition of knowledge and technology needed for decisions on human exploration missions beyond Earth orbit.

Source: NASA's FY2004 Budget Estimate.
Prepared by CRS.

The House-passed version of the FY2004 VA-HUD-IA appropriations bill, and the Senate Appropriations Committee's version of the bill, do not make any major changes to the request for OBPR.

Key Issue: Impact of the Columbia Accident. As discussed earlier, the major issue confronting OBPR is how to recoup from the space shuttle *Columbia* accident. Most of the research aboard *Columbia*'s STS-107 mission was sponsored by OBPR, and a great deal of OBPR's research is intended to be conducted aboard the International Space Station (ISS). With the space shuttle fleet grounded, construction of the space station is suspended. Also, the usual three-person ISS crew complement has been temporarily reduced to two. Allocating crew time for conducting scientific research on ISS has been an ongoing issue because NASA states that "2 ½" people are needed to maintain and operate the station. That means that with a three-person crew, only half of one person's time can be devoted to research. With only two crew members aboard, it is not clear how much research can be accomplished.

Assuming that the shuttle returns to flight at some time, and construction of the space station continues, the schedule for scientific research presumably could pick up from where it was prior to the *Columbia* accident. However, prior to the *Columbia* accident, many questions were unanswered about how much research could be conducted on ISS. The partners in the ISS program agreed at the beginning that after construction of the space station was completed, the space station would be staffed by seven people (rotating on 4-6 month shifts). Several crew members would be able to devote their entire time to scientific research, often cited as one of the main reasons for building a space station. In 2001, however, the Bush Administration took several steps to deal with the revelation of $4.8 billion in cost growth on the space station program. Among them, it directed NASA to truncate construction of the space station at a phase it calls "core complete" where the space station crew size would remain at three instead of growing to seven. It also cut $1 billion from OBPR's research budget for the space station, and reduced the annual shuttle flight rate to ISS to four (from six) for budgetary reasons. This meant less "upmass" (mass being taken up to the space station) available for scientists to send experiments to ISS.

Just before the *Columbia* accident, NASA was taking steps that suggested a relaxation of some of these decisions. For example, it announced that the shuttle flight rate to the station would increase to five per year, added funds to OBPR's FY2004 budget request for space station research, and initiated a program to build an Orbital Space Plane to take crews to and from the space station. The Orbital Space Plane (discussed under "Crosscutting Technologies" below) could offer the capability by 2010 to increase the space station's crew size to seven as originally planned. Officially, however, the Bush Administration remains committed only to building the truncated version of the space station.

Thus, the *Columbia* accident has complicated an already complex situation for OBPR. How OBPR adjusts to these complexities, and how much its FY2004 budget will be affected, is unclear at this time. The FY2004 request for OBPR's space station-related activities is $578 million.

Aeronautics Technology. The Aeronautics Technology theme, within the Office of Aerospace Technology, is responsible for the agency's R&D on aeronautics. 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 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.

FY2004 Budget Request and Congressional Action. For FY2004, NASA requested $959.1 million for Aeronautics Technology. A comparable figure (in full-cost accounting) is not available for FY2003 appropriations. The shift to full-cost accounting is particularly significant for the Aeronautics Technology theme, because it is a major user of facilities such as wind tunnels, which were previously budgeted under a separate account.

The FY2004 budget request for Aeronautics Technology includes three initiatives (see Table 9), one in each of the theme's three programs: an increased emphasis on aircraft noise reduction in the Vehicle Systems program, accelerated work on the National Airspace System in the Airspace Systems program, and a new effort on aviation security in the Aviation Safety and Security program (formerly known as the Aviation Safety program).

The requested budget for Vehicle Systems is $573.5 million. The noise reduction initiative would be part of this program. Other changes in FY2004 would include the conclusion of work on ERAST (a remotely piloted aircraft for demonstrating long-duration flight at high altitudes) and Hyper-X (a pilotless aircraft, called X-43, for demonstrating flight at hypersonic velocities), although work on Hyper-X would continue as part of the Next Generation Launch Technology program (part of the Space Launch Initiative). The ERAST program's Helios aircraft was destroyed on June 26, 2003, when it crashed into the Pacific near Hawaii during a shakedown flight. A mishap investigation board has been appointed. The first Hyper-X test flight ended in failure in June 2001 and one of the three X-43A craft was destroyed. The X-43A mishap investigation board [http://www.dfrc.nasa.gov/Newsroom/NewsReleases/2003/03-43.html] released its findings in July 2003. A second Hyper-X test flight, using another X-43A, is planned for Fall 2003.

The requested budget for Airspace Systems is $217.1 million. This sum includes $27 million for the NASA Exploratory Technologies for the National Airspace System (NExTNAS) initiative. NASA plans to expand the NExTNAS initiative significantly in future years, to $176 million in FY2008.

The requested budget for Aviation Safety and Security is $168.5 million. This total includes $21 million for the new Aviation Security initiative, whose largest component will be in the area of aircraft and systems hardening. NASA plans to expand its efforts in aviation security further in future years, to a peak of $58 million in FY2007.

Table 9: FY2004 Aeronautics New Initiatives

(in $ millions)

Initiative	FY04 Request	FY04-08 Estimate	Comments
Aviation Security	21	196	Addresses critical aviation security needs that NASA is uniquely qualified to provide, and develops technology for commercial aircraft and airspace protection.
National Airspace System Transition Augmentation	27	100	Enables technology, in cooperation with FAA, to transition to a next-generation National Airspace system to increase capacity, efficiency, and security of the system.
Quiet Aircraft Technology Acceleration	15	100	Accelerates development and transfer of technologies that will reduce perceived noise in half by 2007 compared to the 1997 state-of-the-art.

Source: NASA's FY2004 Budget Estimate. Prepared by CRS.

In the FY2004 VA-HUD-IA appropriations bill, the House provided funding increases for Aeronautics Technology in several areas. These include $1 million for aircraft engine research, $1 million for small aircraft transportation systems (SATS),

$1.5 million for intelligent flight control systems, $500,000 for development of a navigation aid (ARGUS), $2 million for research on an aircraft surveillance system (ADS-B), and $5 million for ground-based turbulence detection (Project SOCRATES). The House also directed NASA to report on efforts to establish an interagency National Program Office for coordination of air traffic management activities and to report by March 31, 2004, on how NASA's National Airspace System initiative is being integrated with the National Program Office. The House report did not specify the total funding increase for Aeronautics Technology or allocate the increases noted above to particular program areas within the theme.

The Senate Appropriations Committee report expressed concern about "the steady decline in recent years" in NASA's requested funding for aeronautics R&D. It recommended increases of $15 million in each of three areas: future aircraft, especially supersonic flight; future aviation systems, especially aviation security and air traffic management; and technologies with direct application to military aircraft. The Senate report also recommended an increase of $5 million to fund development of a five-year aeronautics research budget, to be prepared by March 1, 2004. The Senate report recommended several other increases for individual aerospace projects, but did not specify which of these are specifically related to aeronautics.

Key Issue: Funding. The main issue for the Aeronautics Technology theme is its overall funding level. Funding for aeronautics R&D has been reduced significantly since its FY1998 peak of $920 million (*not* expressed in full-cost accounting terms). The level of the FY2004 request and NASA's plans for further reductions in future years have proved contentious among congressional supporters of the program. Supporters argue that more R&D in this area is needed to maintain the health of the U.S. aviation industry and the international competitiveness of U.S. aircraft manufacturers. NASA states that future funding levels may increase from current plans as the result of collaborative efforts now being discussed among NASA, the Federal Aviation Administration, and other agencies with interests in aviation.

The FY2004 policy debate over aeronautics R&D is likely to make frequent reference to the November 2002 *Report of the Commission on the Future of the United States Aerospace Industry*.[21] The recommendations of this congressionally established commission included specific goals for improved aviation system capacity, safety, speed, noise, and emissions, as well as a significant increase in federal support for basic aerospace research. Other key recent reports include the January 2001 European Union document *European Aeronautics: A Vision for 2020*,[22] whose recommendations for increased aeronautics R&D funding in Europe have contributed to U.S. concerns about international competitiveness, and *The NASA*

[21] The aerospace commission report is available online at [http://www.aerospacecommission.gov]. See also CRS Report RS21455, *The Aerospace Commission Report: A Synopsis, and Commission Recommendations for Congressional Action*, by Amanda Jacobs and Marcia S. Smith.

[22] The European *Vision 2020* report is available online at [http://europa.eu.int/comm/research/ growth/aeronautics2020/en/index.html].

Aeronautics Blueprint,[23] issued in February 2002, in which NASA presented its technology vision for aviation. The National Academy of Sciences is conducting an external review of the Aeronautics Technology theme, but the report of that review is not expected until after the completion of FY2004 appropriations action.

Education. The Office of Education is responsible for the Education Enterprise. It has one theme: Education Programs. In previous budgets, the activities in the Office of Education appeared under the budget heading "Academic Programs." These activities have been reorganized, consolidating programs that had been in NASA's Office of Human Resources & Education, and the Office of Equal Opportunity Programs. 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 [http://www.education.nasa.gov/spacegrant/index.html].

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.

FY2004 Budget Request and Congressional Action. NASA is requesting $169.8 million for the Office of Education. Congress appropriated $202.2 million in FY2003. The Education Enterprise has one new initiative in FY2004 (see Table 10).

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[23] *The NASA Aeronautics Blueprint* is available online at [http://www.aerospace.nasa.gov/aero_blueprint].

Table 10: FY2004 Education New Initiative
(in $ millions)

Initiative	FY04 Request	FY04-08 Estimate	Comments
Education Initiative	26	130	Includes funds for the Educator Astronaut program, the NASA Explorers Schools Program, a Scholarship for Service program, and Explorer Institutes.

Source: NASA's FY2004 Budget Estimate.
Prepared by CRS.

In the FY2004 VA-HUD-IA appropriations bill, the House added $6.225 million for the National Space Grant and Fellowship program, which would bring the program to a level of $25.325 million for FY2004. The committee stated that this would fund the current core program in 52 Space Grant Consortia, including 35 states at $465,000 each, 17 states at $300,000 each, and $3.6 million for Workforce Supplement Awards. Some of the other congressionally directed funding additions in the bill may also come under this office, although it is not specified in the report on the bill. The Senate Appropriations Committee did not make any major changes to this account, but included a number of congressionally directed spending items.

Key Issue: "Educator Astronauts". Mr. O'Keefe has made education one of his priorities as NASA Administrator, elevating it to "enterprise" status within the agency and consolidating many of NASA's education activities into a single office.

Mr. O'Keefe also is expanding an effort initiated by his predecessor, Mr. Daniel Goldin, to resume launching educators into space. NASA's earlier program to launch teachers into space ended after the 1986 space shuttle *Challenger* accident that claimed the life of "teacher in space" Christa McAuliffe. She was part of a "spaceflight participant" program begun by NASA to launch teachers, journalists, and other private citizens into space. NASA was confident that the space shuttle, while risky, was sufficiently safe for private citizens as long as they were adequately trained and understood and accepted the risks. Mrs. McAuliffe was selected for flight after a nationwide competition. Barbara Morgan was selected as her backup, and both went through an approximately 4-month training program together. After the accident, NASA was criticized for allowing a private citizen on the shuttle because it was too risky. Mrs. Morgan returned to teaching third grade in Idaho, but remained committed to the concept of launching educators into space and worked closely with NASA's education programs. In 1998, Mr. Goldin announced that Mrs. Morgan would get her chance to fly on the shuttle, but as a career astronaut, after receiving full training.[24] Mrs. Morgan joined the astronaut corps later that year as NASA's first "educator astronaut." Prior to the *Columbia* accident, she was

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[24] The announcement was made at the same time that NASA decided to send then-Senator John Glenn into space aboard a space shuttle. Senator Glenn was one of the original astronauts chosen in 1959, and, in 1962, was the first American to orbit Earth. He flew on the shuttle in October 1998.

scheduled on the crew of a shuttle mission in November 2003. With the shuttle fleet now grounded, it is not clear when that flight will take place.

In 2002, Mr. O'Keefe announced that he would open opportunities for other educators to become astronauts. In January 2003, NASA opened the nomination process for the "Educator Astronaut Program" and more than 1,600 applications were received. Educators were nominated by their students, families, or friends. According to NASA, the purpose of the program is to generate renewed interest in science and mathematics and cultivate a new generation of scientists and engineers by nominating and recruiting educators for NASA's astronaut corps. NASA expects to select three to six educator astronauts through this process.

In the wake of the *Columbia* accident, some may question whether to proceed with the Educator Astronaut Program. One difference from the previous Teacher in Space program is that now the educators would be fully trained as NASA astronauts rather than undergoing an abbreviated training regimen like Mrs. McAuliffe's. Nonetheless, some may question the concept of launching anyone on the shuttle whose presence is not essential to completing a specific mission.

Space Flight Capabilities

Activities in this account blend those that previously were part of the Human Space Flight account with most of the activities in the Office of Aerospace Technology (everything except aeronautics, as discussed earlier). The latter activities are located under the heading "Crosscutting Technologies." NASA is requesting $7.782 billion for Space Flight Capabilities in FY2004, of which $6.110 billion is for Space Flight, and $1.673 billion is for Crosscutting Technologies.

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 and Flight Support. The last theme merges the previous categories of Payload and Expendable Launch Vehicle (ELV) Support, and Space Communications and Data Systems, together with a few other NASA activities. The $6.110 billion request for this category is allocated as follows: $1.707 billion for the space station; $3.968 billion for the space shuttle; and $434 million for Space Flight Support.

Space Station. The International Space Station (ISS) is designed to serve as a scientific research facility for conducting a range of research activities in biology, physics, and materials science, as well as for Earth and astronomical observations. NASA expects that research performed in the near-zero gravity environment of the space station will result in new discoveries in life sciences, biomedicine, and materials sciences.

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

FY2004 Budget Request and Congressional Action. The FY2004 budget request for the space station program can be viewed in different ways. The amount requested under this budget category is $1.707 billion, but funding in other parts of the budget are also part of the space station program, so the figure could be $2.285 billion or $2.835 billion. The House took no action on the space station program in the FY2004 VA-HUD-IA appropriations bill, pending release of the report on the *Columbia* accident. The Senate Appropriations Committee recommended a $200 million cut to the ISS program.

The funding requested in this budget line is for construction and operation of the space station. 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 International Space Station account. In FY2003, they were included in the OBPR budget.) If those costs are added for FY2004, the request would be $2.285 billion. As with the rest of the NASA budget, however, that request is expressed in full cost terms and therefore is not directly comparable to the amount appropriated for FY2003.

Two other costs arguably should be included in space station costs. First are the costs for the Orbital Space Plane located under "Crosscutting Technologies" in the Space Flight Capabilities account. The FY2004 request for OSP is $550 million, which would yield a total FY2004 request for the space station of $2.835 billion. The Orbital Space Plane is the follow-on to the Crew Return Vehicle (CRV) once planned by NASA to bring crews home from the space station in an emergency. The CRV was included in the space station's budget, and NASA "saved" $1 billion by "indefinitely deferring" the CRV as one way of addressing the $4.8 billion cost growth for ISS revealed in 2001 (see below). Despite NASA's decision to account for this program in a different part of NASA's budget (and under a program called Space Launch Initiative, even though the OSP is not a launch vehicle), it is difficult to make the case that this program should not be included as part of space station costs. Following NASA's practice, CRS does not include the OSP request when showing the FY2004 request for the space station, but notes that this cost probably should be included.

Second are costs for the space shuttle flights that take crews and cargo to ISS. Since 1993, when the current version of the space station program began, NASA has not included shuttle costs in the space station cost estimate or annual budget. In the era of full cost accounting, however, it is difficult to argue that they should be excluded. Since all the shuttle flights scheduled for FY2004 are in support of the space station, some may contend that the entire cost of the space shuttle program should be attributed to the space station budget. Historically, CRS has followed NASA's practice of not including the shuttle costs with the space station budget, so they will not be included here. But the shift to full cost accounting, designed to show a program's actual cost, implies that the shuttle costs should now be included. In fact, since the space station itself primarily supports the mission of the Office of Biological and Physical Research, some could suggest that all these costs should be counted as part of OBPR. NASA has not yet taken that step, however.

Key Issue: After the Shuttle Returns to Flight. Issues facing the space station program while the space shuttle fleet is grounded are discussed above (see "Agency-Wide" Issues). It is important to note, however, that the space station program was the subject of considerable controversy prior to the *Columbia* accident because of repeated cost overruns and cost growth, and is likely to be controversial after the shuttle returns to flight as well.

The number of crew that can live aboard ISS is limited, in part, by the availability of a "lifeboat" to bring them home in an emergency. The lifeboat function is currently served by Russian Soyuz spacecraft (which must be replaced every 6 months) that accommodate three people. Thus, ISS crew size has been limited to a maximum of three (as noted, the size was reduced to two while the shuttle is grounded so resupply requirements would not be as great). The international agreements call for the United States to provide crew return for four additional astronauts once assembly of the space station is completed. In 2001, following the revelation of another $4.8 billion in cost growth (on top of a $7 billion overrun) on the ISS program, the Bush Administration directed NASA to truncate construction at a phase it calls "core complete." As part of that decision, NASA's plan to build a crew return spacecraft was "indefinitely deferred," meaning that space station crew size would be limited to three crew members for the foreseeable future instead of growing to seven. The reduction in crew size affects how much scientific research can be conducted, and how many astronauts from the various countries involved in the program have an opportunity to be part of ISS crews.

At the time of the *Columbia* accident, there were indications that the Bush Administration was softening its position on the ISS program, announcing plans to build an Orbital Space Plane that would allow the crew size to grow from three to seven, as originally planned. However, the Administration remains publicly committed only to building the truncated "core complete" version of the station.

How ISS will evolve in the wake of the *Columbia* accident is unclear at this time. The partners are committed to keeping crews aboard ISS while the shuttle is grounded. If the shuttle is grounded for an extended period, however, that decision may need to be reassessed. The Russians operated seven space stations over three decades without a space shuttle, so it is feasible to keep ISS operating without the shuttle. But ISS was designed to take advantage of the crew- and cargo-carrying capacity of the U.S. space shuttle. Most of the remaining ISS segments can only be launched on the shuttle, and many of the scientific experiments also require the shuttle for launch. If little science can be accomplished, some may question the value of keeping a crew aboard, and the sagacity of asking astronauts and cosmonauts to accept the risks inherent in human spaceflight simply to maintain ISS systems.

Conversely, some question how long ISS could continue to function with no one aboard. Progress spacecraft can dock with ISS automatically to reboost it and keep it at the proper altitude. However, a major system malfunction that could not be remedied by sending commands from ground stations could imperil the station. Assessing the likelihood of such a scenario is difficult.

Another issue is that although Russia is obligated under existing agreements to provide two Soyuz and a certain number of Progress spacecraft each year, Russia has expressed concern for some time about its financial ability to provide those spacecraft. Hence, questions may arise as to how to finance Soyuz and Progress spacecraft if the Russian government is unable to fund them. Under the Iran Nonproliferation Act (INA), NASA is prohibited from paying Russia for such spacecraft unless the President certifies that Russia is not proliferating certain technologies to Iran. (See CRS Issue Brief IB93017 for more on the space station program and the INA.)

Space Shuttle. On February 1, 2003, the space shuttle *Columbia* broke apart as it returned to Earth from a 16-day scientific research mission. All seven astronauts aboard were killed. An investigation is underway. The shuttle fleet is grounded. The *Columbia* tragedy is discussed under Agency-Wide Issues (above) and in CRS Report RS21408.

The space shuttle is a partially reusable launch vehicle capable of taking crews and cargo into 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. *Columbia* was one of four remaining orbiters in the shuttle fleet (*Challenger* was destroyed in the 1986 accident that took the lives of seven astronauts). *Discovery*, *Atlantis*, and *Endeavour* remain.[25]

According to NASA, the primary goals of the space shuttle program are to fly the shuttle safely, meet the flight schedule (the "manifest"), improve mission supportability, and improve the system. NASA itself is the primary customer for the shuttle, although industry, other government agencies, academia, and international entities use shuttle services, usually on a reimbursable basis. In FY2001, NASA planned an average of seven shuttle launches per year. For budgetary reasons, that was cut to six per year in FY2002. For FY2003 and beyond, NASA planned to reduce the annual flight rate to four for budgetary reasons, with the exception of another servicing mission to the Hubble Space Telescope in late 2004. However, in the FY2003 amended budget request (released in November 2002), NASA announced plans to increase the flight rate to five per year beginning in FY2006. Among the many issues NASA must assess in the wake of the *Columbia* tragedy is how many annual shuttle flights can be accommodated with the remaining three orbiters.

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[25] Another orbiter, *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.

The United Space Alliance (USA), a joint venture between Lockheed Martin and Boeing, conducts most of the ground operations associated with the shuttle under contract to NASA. The space shuttle workforce consists of approximately 17,000 contractors and 1,800 civil servants.

FY2004 Budget Request and Congressional Action. For FY2004, NASA is requesting $3.968 billion for the shuttle program. A comparable figure (in full cost accounting) is not available for FY2003 appropriations. Congress did approve the full amount requested for the shuttle in FY2003 ($3.2 billion, not in full cost accounting), and added $50 million to cover the costs of the *Columbia* investigation and resulting required remedial actions. Furthermore, it exempted the shuttle program (both the funding in the shuttle budget line, and shuttle-related personnel and facilities costs in the "Investments and Support" line, a combined total of $3.836 billion in full cost accounting). The House took no action on the space shuttle program in the FY2004 VA-HUD-IA appropriations bill, pending release of the report on the *Columbia* accident. The Senate Appropriations Committee recommended full funding of the shuttle program

Key Issue: Return to Flight. The space shuttle *Columbia* tragedy already has been discussed (see Agency-Wide Issues). Attention is focused on what is needed to fix the shuttle system. After the 1986 *Challenger* accident, the shuttle fleet was grounded for 32 months. However, NASA officials project that the shuttle may return to flight in 2004, although they stress that a firm date cannot be set until they fully understand what must be done to meet the 15 recommendations of the *Columbia* Accident Investigation Board (CAIB) that must be completed before "Return to Flight." CAIB's chairman, Adm. (Ret.) Harold Gehman, stated that he does not believe it will take more than 6-9 months for NASA to comply with the Board's return to flight recommendations. Additional recommendations were made if NASA expects to continue using the shuttle in the long term. For more on the *Columbia* accident and issues for Congress, see CRS Report RS21408. For a synopsis of the CAIB's recommendations, see CRS Report RS21606.

As discussed earlier, the American public and policy makers first must decide whether human space flight is worth its risks and costs. Based on past experience, many expect that decision to be yes. The questions next are what can be done to lower the risk, and how much Congress and the Administration are willing to spend to do that.

NASA has been engaged in a series of "safety and supportability" upgrades to the shuttle for several years. ("Supportability" refers to changes made to combat obsolescence.) Debate over shuttle upgrades became intense during the FY2002 budget cycle after NASA decided to terminate what it earlier had described as its highest priority safety upgrade, the Electric Auxiliary Power Unit, because of cost increases and weight gain. Then, in the original FY2003 budget submission, NASA reduced how much it planned to spend on both safety and supportability upgrades in the FY2002-2006 time period by 34%—from $1.836 billion to $1.220 billion. NASA Administrator O'Keefe insisted the proposed funding level would not compromise safety. In September 2002, NASA canceled its highest priority supportability upgrade, the Checkout and Launch Control System (CLCS) because of cost overruns and schedule delays. Questions began to arise about NASA's abilities to successfully upgrade the shuttle. In FY2004, NASA is requesting funding to begin a "Shuttle Life Extension Program" (SLEP) to ensure the shuttle can safely operate as long as it is needed. How much that program may change in light of the *Columbia* accident is unclear. During consideration of the FY2004 VA-HUD-IA appropriations bill, the House adopted a Hall amendment to use $15 million of the $281 million requested for SLEP to develop concepts to increase crew survivability.

The shuttle program is facing many challenges in its 22nd year of service. *Columbia* was the oldest of the shuttle orbiters—it was used for the very first shuttle flight in 1981. The ill-fated *Columbia* mission was its 28th flight. Each orbiter is designed to make 100 flights, but many now wonder if age was a contributing factor to the accident. If so, this may raise questions about the health of the three remaining orbiters. These questions come on the heels of NASA's November 2002 announcement that it will continue to rely on the shuttle until at least 2015, and perhaps 2020 or longer.

Some may ask why NASA does not procure new shuttle orbiters if aging is the problem. The last orbiter, *Endeavour*, was built following the 1986 *Challenger* accident. *Endeavour* made its first flight in 1992. It cost $1.8 billion (then-year dollars), a cost that was lower than expected in part because "structural spares" (i.e. major segments of the fuselage) were available since NASA earlier had considered building an additional orbiter. There are no orbiter structural spares today, and the company that built the orbiters (the space division of Rockwell International) was bought by the Boeing Company in 1996. It is not expected that sufficient tooling and skilled workers are available to build more orbiters without substantial cost and time. However, lacking a replacement for the shuttle, and NASA's intent to continue operating the shuttle until 2015 or beyond, it is possible that a decision could be made to rebuild that capability.

NASA, sometimes jointly with the Department of Defense (DOD), has been trying to build a replacement for the shuttle, rather than acquiring more orbiters. Its attempts to do so over the past 20 years have failed, however, in part because of overly optimistic expectations about the availability of new technologies, and about the market for such a new "2nd generation" reusable launch vehicle (RLV). NASA's November 2002 announcement that it would continue to rely on the shuttle was based on the conclusion that an economic case cannot be made at this time for building a 2nd generation RLV to replace the shuttle. Instead, NASA wants to build an Orbital Space Plane to take crews to and from the space station, and invest in technology for the next six years to enable a decision in 2009 on what new launch vehicle to build (see Crosscutting Technologies below). In the aftermath of the *Columbia* accident, some policy makers want NASA to reinvigorate its efforts to build a replacement for the shuttle, and others want NASA to accelerate the OSP, even though it would not have the crew or cargo capacity of the shuttle. (As currently envisioned by NASA, the OSP would provide a capability for four crew members, instead of the seven that can be accommodated on shuttle, and could only carry cargo if the crew seats were removed from the vehicle. Also, OSP is not itself a launch vehicle, as is the shuttle).

Yet another issue under discussion is the relationship between NASA and its contractors on the shuttle program. As noted, there are approximately 17,000 contractors working on the shuttle program. United Space Alliance (USA) conducts most of the operations for the shuttle under the Space Flight Operations Contract (SFOC), a 6-year contract, with two 2-year options, that was signed in 1996. NASA exercised the first of those 2-year options in 2002, extending the contract to September 2004. Questions have been raised for many years by the Aerospace Safety Advisory Committee (ASAP), Congress, and others about the safety implications of transitioning so much of the shuttle work to a contractor because of budget constraints, personnel reductions, and the loss of skills.[26] In the aftermath of the loss of *Columbia*, those concerns are being carefully revisited.

Space and Flight Support. This new 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.

FY2004 Budget Request and Congressional Action. The FY2004 request is $434.3 million. A comparable figure (in full cost accounting) for FY2003 appropriations is not available. The House made no major changes to this subaccount in the FY2004 VA-HUD-IA appropriations bill. Nor did the Senate Appropriations Committee.

Crosscutting Technologies. This new budget category represents funding for the activities of the Office of Aerospace Technology, except for aeronautics, which is included in the Science, Aeronautics, and Exploration account (discussed earlier). Crosscutting Technologies has three themes: Space Launch Initiative, Mission and Science Measurement Technology, and Innovative Technology Transfer Partnerships. The total request for Crosscutting Technologies is $1.673 billion. That is allocated as follows: Space Launch Initiative, $1.065 billion; Mission and Science Measurement Technologies, $438 million; and Innovative Technology Transfer Partnerships, $169 million.

Space Launch Initiative: OSP and NGLT. The Space Launch Initiative (SLI) has undergone a metamorphosis since the FY2003 budget was originally submitted. The changes were announced when NASA submitted an amended FY2003 budget request to Congress in November 2002. The SLI program had been focused on developing technologies to build a "2nd generation" reusable launch vehicle (RLV) to replace the space shuttle (which is the 1st generation RLV), with a decision expected in 2006 on what design to build. The new RLV was intended to significantly reduce the cost of launching people and cargo into space. Now, SLI is focused on (1) developing an Orbital Space Plane (OSP) to take crews to and from the space station, and (2) a Next Generation Launch Technology (NGLT) program to develop expendable and reusable launch vehicle technologies to permit a decision in 2009 on what new vehicle to build. The new vehicle would be for taking cargo only, not crews, into space. Although it is included in the "Space Launch Initiative," the Orbital Space Plane is not a launch vehicle. It is a spacecraft to take crews to and from the space station. It will be launched into space aboard an existing expendable

[26] See CRS Report RS21419 for excerpts from reports and testimony about shuttle safety.

launch vehicle (such as an Atlas 5 or Delta 4), not a new reusable launch vehicle. Hence, its inclusion in a budget category for developing space launch technologies, instead of in the space station budget, may be controversial.

FY2004 Budget Request and Congressional Action. The FY2004 request for the reformulated Space Launch Initiative is $1.065 billion, composed of $550 million for the Orbital Space Plane and $514.5 million for Next Generation Launch Technology. Comparable figures (in full cost accounting) for FY2003 appropriations are not available. The House took no action on the Orbital Space Plane or Next Generation Launch Technology programs in the FY2004 VA-HUD-IA appropriations bill, pending release of the report on the *Columbia* accident. The Senate Appropriations Committee made a number of recommendations about these programs, but did not change the funding. The OSP comments are discussed below. Regarding NGLT, the committee expressed concern that NASA is not maintaining control over its investment in NGLT, and directed NASA to report by January 31, 2004 on outyear costs for projects within the NGLT program, the criteria for selecting technologies for investment, and the metrics used to determine whether or not to continue particular projects (p. 122).

Key Issue: Orbital Space Plane—"Crew Return" versus "Crew Transport". As noted earlier, crew size aboard the International Space Station (ISS) is limited in part by the number of people that could be returned to Earth in an emergency, such as a catastrophic hull depressurization or a fire, via a "lifeboat." Today, one Russian Soyuz spacecraft, which can accommodate three people, is always docked at ISS to provide this lifeboat function. Under international agreements that govern the ISS program, Russia is required to provide that lifeboat capability for three people throughout the duration of the space station program. Those agreements also require NASA to provide a lifeboat, or "crew return vehicle," for four more crew members by the time assembly of the space station is completed.[27] This would allow the size of the "Expedition" crews aboard ISS to grow to seven people as stipulated in those agreements.

NASA indefinitely deferred its plans to build a Crew *Return* Vehicle (CRV), however, in the wake of the $4.8 billion cost growth revealed in 2001. At the time, NASA estimated the cost of the CRV as about $1.2 billion and expected it to be ready in 2006. A CRV would be able only to return crews to Earth from the space station (it would be taken into orbit, unoccupied, via the space shuttle). By contrast, a Crew *Transfer* Vehicle (CTV) could take people both to and from the space station. When Mr. O'Keefe became NASA Administrator, he decided that if a crew return capability was to be built, a CTV would be preferable because of its additional capabilities. In an amended FY2003 budget request, submitted to Congress in November 2002, the Bush Administration proposed a program to design and build a CTV, even though the Administration currently is committed only to building the "core complete" version of the space station (discussed above), which does not

[27] Memoranda of Understanding (MOUs) between NASA and its counterpart agencies—the European Space Agency, the Russian Aviation and Space Agency (Rosaviakosmos), the Science and Technology Agency of Japan, and the Canadian Space Agency—specify the crew return responsibilities of the United States and Russia.

include either a U.S. CRV or a CTV. Many viewed this as an indication that the Bush Administration eventually would agree to building the space station as originally planned, capable of supporting a crew of seven.

NASA calls the CTV an "Orbital Space Plane" (OSP). The agency proposed $2.405 billion for the OSP program for FY2003-2007, some of which ($882 million) would be shifted into OSP from funding that had been allocated for building a 2nd generation RLV. For FY2003, the request was $296 million. Congress generally approved this reformulation of the SLI program in the FY2003 Consolidated Appropriations Act (P.L. 108-7), but neither approved nor rejected the specific amount for OSP, giving NASA latitude to decide on the FY2003 funding level in its operating plan. In its initial FY2003 operating plan, NASA shows $367.8 million being allocated to OSP (not expressed in full cost accounting).

NASA's plan is to conduct design studies for OSP through FY2004, after which it will decide whether to proceed with development. NASA emphasizes that the $2.405 billion figure for FY2003-2007 is preliminary, since it does not yet know what design will be selected. NASA issued a set of "level 1" (basic) requirements for the OSP in February 2003, and "level 2" (more detailed) requirements in September 2003. As long as the design meets those requirements, the agency insists that it does not have a preference for whether the OSP is reusable or expendable, has wings, is a capsule, or any other specific feature. In fact, it does not have to be one vehicle. It must support four crew members on the space station, but could be two spacecraft, each for two people, for example. The point is that the agency wants to give industry latitude on how to meet the requirements. The FY2004 request for OSP is $550 million, with a 5-year (FY2004-2008) estimate of $3.7 billion.

NASA's plan in early 2003 was for OSP to be available first in a CRV mode in 2010, and in 2012 as a CTV (plans to accelerate it are discussed below). That would mean that Soyuz spacecraft would be needed until 2010 as lifeboats for ISS Expedition crews. In the existing international agreements that govern the ISS program, Russia is obligated to ensure that one Soyuz is docked to ISS through the lifetime of the station (with each Soyuz spacecraft being replaced every 6 months). A 1996 U.S.-Russia agreement stipulates that through completion of assembly of the space station, Russia will provide crew return capability for three ISS Expedition crew members who comprise crews that are composed of two Americans and one Russian, or two Russians and one American. Eleven Soyuz spacecraft were specified for this purpose. According to NASA, that commitment will be satisfied in the spring of 2006. By 2006, the U.S. CRV was expected to be available, allowing crew size to increase to seven. In the event the U.S. CRV were not yet available, the agreement simply calls on the parties to "discuss appropriate action." Thus, there could be a several year gap when Americans might be limited to residency aboard ISS only when the U.S. space shuttle is docked. (Russia is obligated to continue to keep one Soyuz docked at the station at all times, but after 2006 would control who could use it, with no guarantee that Americans would be included.) As noted in the earlier discussion about the space station program, the Iran Nonproliferation Act prevents NASA from paying Russia to use Soyuz unless Russia does not proliferate certain technologies to Iran.

Even before the *Columbia* accident, some argued that NASA should focus on building a simple vehicle that could be ready by 2006, rather than 2010, to ensure that the space station can be fully utilized for scientific research. In the aftermath of the *Columbia* accident, many argue that OSP should be accelerated because there now are only three orbiters. NASA has indicated to its contractors that it would like to have OSP available two years earlier (by 2008). *Space News* reported in its September 1, 2003 issue that it could cost $14 billion through 2009 to build the OSP on an accelerated schedule, compared with the $3.7 billion in NASA's project budget for FY2003-2008.

The Senate Appropriations Committee (S.Rept. 108-143) made a number of comments and recommendations about OSP, including that it is skeptical that OSP is the only approach for NASA to take astronauts to and from the space station (p. 121). The committee also expressed concern that the OSP program not experience the same management problems and cost overruns of the space station program, and directed the Administration to create an independent oversight committee to examine the OSP's design, technology readiness and cost estimate.

Mission and Science Measurement Technology. In the FY2003 budget, this was called "Pioneering Revolutionary Technology." Its objectives are to develop science-driven architectures and technology, create knowledge from scientific data, and develop capability for assessing and managing mission risk. Its three programs are: the Computing, Information, and Communications Technologies Program, the Engineering for Complex Systems Program, and the Enabling Concepts and Technologies Program.

FY2004 Budget Request and Congressional Action. The FY2004 request is $438.4 million. A comparable figure (in full cost accounting) is not available for FY2003 appropriations. The House made no major changes to this subaccount in the FY2004 VA-HUD-IA appropriations bill. Nor did the Senate Appropriations Committee.

Innovative Technology Transfer Partnerships. In the FY2003 budget, the proposed Innovative Technology Transfer Partnerships effort was called Commercial Technology Program. According to the FY2004 budget estimate, this theme is responsible for technology transfer, and for awarding contracts under the Small Business Innovation Research (SBIR) and the Small Business Technology Transfer (STTR) programs. Both SBIR and STTR were created by Congress and apply to all government agencies that conduct a certain level of research and development (R&D).[28] They involve set-asides for small businesses of a percentage of each agency's extramural R&D funds. The FY2004 budget request for this activity is a significant change from previous years. NASA proposes terminating many of its technology transfer activities (discussed below).

FY2004 Budget Request and Congressional Action. The Administration's FY2004 request is $169.3 million. A comparable figure (in full cost accounting) is

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[28] For more information on the SBIR and STTR programs see CRS Report 96-402, *The Small Business Innovation Research Program*, by Wendy H. Schacht.

not available for FY2003 appropriations. The FY2004 VA-HUD-IA appropriations bill, as passed by the House, provides an increase of $24 million to the President's budget request for continuation of the Commercial Technology Program targeted for elimination. S. 1584, as reported to the Senate from the Committee on Appropriations, would fund two of the technology transfer elements including the Glenn Research Center at $2 million and the National Technology Transfer Center at $2 million.

Key Issue: Termination of the Commercial Technology Program. Responsibility for technology transfer is conferred upon NASA in the 1958 National Aeronautics and Space Act (the "Space Act") that created NASA. In pursuit of this mission, NASA has established a series of programs and institutions designed to promote cooperative R&D leading to the commercialization and application of technology. The Commercial Technology Program, located in the Office of Aerospace Technology, facilitates the creation of technology partnerships among government, industry, and academia to promote the commercialization of R&D developed within the NASA research endeavor. "Space Act Agreements" form the legal construct under which these cooperative arrangements take place (similar to "Cooperative Research and Development Agreements" created under the Stevenson-Wydler Technology Innovation Act[29]). The movement of technology to the private sector is expedited by technology transfer agents associated with the Offices of Research and Technology Applications (ORTA) located at the agency's ten field centers (including JPL), six Regional Technology Transfer Centers, and the National Technology Transfer Center. Ten business/technology incubators assist small companies develop NASA technologies. Several publications, including *Innovations*, *Spin-off*, and *TechBriefs*, as well as an agency-wide technology transfer database, *TechTracS*, augment these efforts. The Small Business Innovation Research Program is also considered an element of the technology transfer activity. Licensing of NASA-owned patents is handled by the Office of the General Counsel.

Since its inception, NASA has approached technology transfer in various ways; these efforts appear to have resulted in a fairly extensive amount of cooperative work leading to the commercialization of new technologies for the marketplace. In the FY2004 budget, NASA has proposed a reorganization of the technology transfer endeavor to reflect NASA's new mission and vision. According to the agency, this mission is to "pursue activities unique to [NASA]" and includes a "shift in emphasis from spin-out (non-aerospace) to spin-in (NASA applications)."[30] The focus is on cooperative R&D leading to the commercialization of technologies of value to NASA. To accomplish this goal, the agency proposes a "re-formulation" of the technology transfer program based on a new theme of "Innovative Technology Transfer Partnerships."

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[29] For more information see CRS Issue Brief IB85031, *Technology Transfer: Use of Federally Funded Research and Development*, by Wendy H. Schacht.

[30] NASA designates "spin-in" as the agency's internal application of new technologies developed by the private sector. This concept is in contrast to "spin-out" or "spin-off" where NASA technologies are applied to industry needs.

As outlined in the FY2004 budget proposal, the major expenditure of funds in pursuit of the establishment of innovative technology partnership will be through the Small Business Innovation Research program. Funding for this activity is derived from a 2.5% set-aside of each agency's extramural R&D budget. Another government-wide effort, the Small Business Technology Transfer program, also will be a part of this new initiative. Currently financed by a 0.15% set-aside of the agency's extramural R&D budget, the set-aside will increase to 0.3% in FY2004 as mandated by P.L. 107-50, the Small Business Technology Transfer Program Reauthorization Act. These programs will focus on the development and support of mechanisms to "accelerate and augment development of mission relevant SBIR technology for NASA missions" as well as on efforts to move SBIR technology into the marketplace. To this end, NASA intends to propose statutory changes to permit the application of SBIR funds, matched by private sector money, for "post-phase II dual use technology development." Current law allows agencies to use government funds, but not those dedicated to the SBIR activity, to commercialize SBIR technologies necessary to achieve mission requirements.

An additional component of the new technology transfer initiative is what the agency terms the "NASA Enterprise Engine." The purpose of this activity, according to NASA, is to facilitate "spin-in" by supporting the development of "innovative, dual-use technologies" as well as to assist industry in the commercialization of these technologies. While NASA notes that this will not be a "pure venture capital fund," the agency will invest federal funds in conjunction with private sector financing to support those R&D activities needed to generate new technologies.[31] From the available information it is unclear what this approach entails, but indications are that a mechanism "similar" to the private sector *In-Q-Tel* program funded by the Central Intelligence Agency will be created as an "additional management tool that complements existing programs." The effort is to be managed by the NASA's Office of the Administrator, rather than the Office of Aerospace Technology.

The Catalog of Federal Domestic Assistance states that over 200,000 inquiries were serviced by NASA technology transfer agents in the past year. However, the new Innovative Technology Transfer Partnership Initiative requires termination of the Commercial Technology Program, resulting in the discontinuation of many of those organizations within which these transfer agents reside, including the Regional Technology Transfer Centers and the business/technology incubators. *Spin-off* will cease publication. The Commercial Technology Activity at the Jet Propulsion Laboratory would also end. The operation and responsibilities of the National Technology Transfer Center would be altered to reflect the new priorities and the work competed. However, H.R 2861, the FY2004 VA-HUD-IA appropriations bill passed by the House, would provide an additional $24 million to the President's budget to continue the Commercial Technology Program. S. 1584, as reported to the Senate from the Committee on Appropriations, would fund two of the technology transfer elements including the Glenn Research Center at $2 million and the National Technology Transfer Center at $2 million.

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[31] For a discussion of laws related to federal loan or federal loan guarantee programs see CRS Report RL30346, *Federal Credit Reform: Implementation of the Changed Budgetary Treatment of Direct Loans and Loan Guarantees*, by James M. Bickley.

The proposed reorientation of the NASA technology transfer program raises several issues that Congress may wish to explore. Foremost among possible concerns is the effect closing the Technology Transfer Centers and the incubators may have on individual firms, cooperative R&D, and the NASA mission given the extensive use of these facilities and/or expertise documented above. While the SBIR and STTR programs have proven to be successful across the federal government, issues remain regarding the operation of these activities that may raise questions as to their contribution to technology transfer within the context of the NASA goal of "spin-in." Congress may want to address whether reliance on these specific programs to the exclusion of other forms of technology transfer might compromise the mission responsibilities of NASA. In addition, as the move toward a "modified" federal venture capital program is proposed in the form of the "Enterprise Engine," Congress may find instructive a discussion of the legal, legislative, and political concerns associated with such an initiative.

Out-Year Budget Projections

NASA's FY2004 budget estimate contains the out-year budget projections shown in Table 11. Such projections are always subject to change, but can be indicative of the direction in which the Bush Administration wants NASA to head. Recovery from the space shuttle *Columbia* accident could have a significant effect on these out-year projections.

The projections in the FY2004 budget request are somewhat more generous than in the FY2003 request. In the FY2003 request, NASA's budget was anticipated to rise 3.8% from FY2003 to FY2004, 1.9% from FY2004 to FY2005, 2.6% from FY2005 to FY2006, and 3.2% from FY2006 to FY2007. In total, the budget was forecast to rise 11.8% from FY2003 to FY2007. The new forecast is for the budget to rise 15% from FY2004 to FY2008.

Table 11: NASA FY2004 and Out-Year Budget Estimate
(in $ millions)

Category	FY2004	FY2005	FY2006	FY2007	FY2008
Science, Aeronautics & Exploration	**7,661**	**8,269**	**8,746**	**9,201**	**9,527**
Space Science	4,007	4,601	4,952	5,279	5,573
Earth Science	1,552	1,525	1,598	1,700	1,725
Bio. & Phys. Res.	973	1,042	1,087	1,118	1,143
Aeronautics	959	932	939	934	916
Education	170	169	169	170	170
Space Flight Capabilities	**7,782**	**7,746**	**7,881**	**8,066**	**8,247**
Space Flight	6,100	6,027	6,053	6,198	6,401
Space Station	*1,707*	*1,587*	*1,586*	*1,606*	*1,603*
Space Shuttle	*3,968*	*4,020*	*4,065*	*4,186*	*4,369*
Space Flight Support	*434*	*419*	*402*	*407*	*429*
Crosscutting Technologies	1,673	1,720	1,828	1,868	1,846
Space Launch Initiative	*1,065*	*1,124*	*1,221*	*1,257*	*1,224*
Mission & Sci. Msmt	*438*	*435*	*439*	*439*	*444*
Innovative Tech. Trans.	*169*	*161*	*168*	*172*	*179*
Inspector General	**26**	**28**	**29**	**30**	**31**
Total	**15,469**	**16,043**	**16,656**	**17,297**	**17,806**
Percentage Change from Previous Year	.9*	3.7	3.8	3.8	2.9

Source: NASA FY2004 Budget Estimate (except for percentage change from previous year for FY2004, which was calculated by CRS).
Prepared by CRS.
*Compared to NASA's FY2003 appropriation level of $15.339 billion. If compared to the FY2003 *request*, the FY2004 request is 3.1% higher.

Over the next five years (FY2004-2008), funding for Science, Exploration, and Technology would increase 24%. The major driver in the increase for Science, Exploration, and Technology is the Space Science Enterprise, which would receive a 36% increase over that 5-year period (from $4.07 billion in FY2004 to $5.573 billion in FY2008). A large portion of that increase apparently would be devoted to Project Prometheus. Funding for the Earth Science Enterprise would increase about 10%, from $1.552 billion to $1.725 billion. The Biological and Physical Research Enterprise would rise 17%, from $973 million to $1.143 billion. That budget estimate was developed prior to the *Columbia* accident, however, and is especially subject to change. Aeronautics would decline by 4%, from $959 million to $916 million. Education would remain level at $170 million.

Funding for the Space Flight Capabilities would increase by 6% over the 5-year period. Space flight—which includes the space station and space shuttle—would increase approximately 5% from $6.110 billion to $6.401 billion. This profile could change, of course, depending on the outcome of the space shuttle *Columbia* accident investigation. As formulated prior to the accident, funding for the shuttle would increase (from $3.968 billion to $4.369 billion), and space station construction and operations would decline (from $1.707 billion to $1.603 billion). Funding for

Crosscutting Technologies would rise 10%, from $1.673 billion to $1.846 billion, as funding for the Orbital Space Plane ramps up.