

## NASA R&D Gains, But Steep Cuts Loom for Research

### AAAS R&D Funding Update on R&D in the FY 2007 NASA Budget

(This analysis is a preview of the NASA chapter in the forthcoming *AAAS Report XXXI: Research and Development FY 2007*, a comprehensive look at the President's budget for R&D in FY 2007. This analysis contains revised AAAS estimates of NASA R&D, different from figures originally presented in the President's budget. More tables and continually updated supplemental materials on R&D in the FY 2007 budget can be found on the AAAS R&D Web site at <http://www.aaas.org/spp/rd>.)

#### Highlights

- The National Aeronautics and Space Administration (NASA) may be a Bush Administration priority because of the President's Vision for Space Exploration of returning humans to the moon as a stepping stone to a Mars mission, but like other agencies NASA is being asked to do more with flat funding. **The total NASA budget of \$16.8 billion in FY 2007 would be just 1.0 percent more than in 2006** (see Table II-12).
- The non-R&D Space Shuttle budget is expected to fall \$721 million to \$4.1 billion after the Shuttle returns safely to flight in spring 2006 and NASA finishes repairing hurricane-damaged Shuttle facilities. **The Shuttle savings would help boost NASA R&D by \$907 million or 8.0 percent to \$12.2 billion** (see Table II-12), putting NASA near the head of the class among the top R&D funding agencies.
- But an acceleration of NASA efforts to develop human space vehicles to replace the Space Shuttle no later than 2014 would eat up the entire R&D increase and more, leaving all other NASA R&D with cuts. The Constellation Systems program to develop the new Crew Exploration Vehicle and Crew Launch Vehicle ballooned from \$422 million last year to \$1.7 billion in 2006, and would nearly double to \$3.1 billion next year (see Table II-12).
- **The heavy emphasis on development of new space vehicles over NASA's support of basic and applied research in the 2007 budget would lead to a 16.5 percent cut in NASA's research portfolio down to \$3.3 billion.** Although NASA would protect the Science program overall from cuts, aeronautics research would plummet 18 percent to \$724 million and the remnants of the life and physical sciences effort would tumble 56 percent to \$275 million after a 30 percent cut this year.
- The International Space Station construction project would receive \$1.8 billion, up 3.3 percent, in anticipation of the Space Shuttle returning to its role of transporting Station components into space.

#### NASA R&D in the FY 2007 Budget

The National Aeronautics and Space Administration (NASA) continues to forge ahead with its full program of flying the Space Shuttle, building the Space Station, funding research across a broad range of disciplines, and developing the next generation of space vehicles, but tight budget constraints in the overall federal budget and NASA Administrator Michael Griffin's promise to do everything within a budget rising no faster than the rate of inflation are forcing tough choices in the agency's priorities. NASA's total budget of \$16.8 billion in FY 2007 would be just 1.0 percent or \$169 million more than the current year, although the increase would be higher if FY 2006 emergency funds to repair hurricane-damaged NASA Shuttle facilities are excluded (see Table II-12).

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After the Space Shuttle's brief return to flight in July 2005 followed by another grounding to fix foam shedding during the launch, the Shuttle is expected to fly again later this spring and return to normal operations in 2007, allowing for a sharp cut in the Shuttle budget after several years of ballooning costs to retool the Shuttle in the aftermath of the 2003 Columbia disaster and to rebuild Gulf Coast facilities damaged by Hurricane Katrina. The Space Shuttle budget, after hitting \$5.0 billion last year and dropping slightly to \$4.8 billion this year, is expected to fall 15 percent to \$4.1 billion in 2007, freeing up money to transfer to the R&D programs that make up the rest of the NASA budget.

**NASA's R&D funding would climb \$907 million or 8.0 percent to \$12.2 billion** (see Table II-12), continuing a rebound from a dismal 2005 when Shuttle cost overruns forced the agency to siphon money the other way from R&D programs to the Shuttle. Even in a year when several R&D funding agencies would enjoy substantial increases to their R&D programs as part of the President's American Competitiveness Initiative (ACI) to boost physical sciences research, NASA would have the second-largest percentage increase for R&D among the top R&D funding agencies, behind only the National Science Foundation's (NSF) ACI-fueled 8.3 percent increase.

**But an acceleration of NASA efforts to develop next-generation human space vehicles to replace the Space Shuttle would take up the entire R&D increase and more, leaving all other NASA R&D with declining funding.** NASA has reorganized its budget to create the Constellation Systems program to develop a new Crew Exploration Vehicle (CEV) and Crew Launch Vehicle (CLV) to replace the Space Shuttle no later than 2014 as the primary means of getting humans into space. This large program to fund development of the CEV, CLV, and related technologies quadrupled from just \$422 million last year to \$1.7 billion this year, and would nearly double in 2007 to \$3.1 billion, a \$1.3 billion increase that outstrips the \$907 million increase for all NASA R&D. Although the goal is to have the new vehicles ready by 2014, NASA will try to get them launched as soon as 2012 and possibly sooner, mindful that the Shuttle's planned retirement by 2010 could leave a long gap in which the U.S. would have no vehicles capable of carrying astronauts into space.

**The large increase for spacecraft development would leave most NASA research programs with sharp funding cuts, following similar cuts in 2006** (see Figure 1). Ironically, NASA is a large supporter of physical sciences research but was left out of the American Competitiveness Initiative (ACI), and its support for physical sciences research and other research would fall dramatically in the 2007 budget. **NASA's basic and applied research support would fall 16.5 percent down to \$3.3 billion.** Aeronautics research funding would tumble 18 percent down to \$724 million in 2006 after large cuts the previous two years; in real terms, the aeronautics research portfolio would be less than half its size of a decade ago (see Figure 2). Human Systems Research and Technology would fare even worse and be cut in half in just one year, from \$624 million down to \$275 million in 2007, after enduring a 30 percent cut this year. Human Systems would be just a shadow of its former self, when it was the Biological and Physical Research portfolio and funded a broad range of life and physical sciences. Now, the program is tightly focused on research related to human exploration of the solar system such as physiology research and behavioral research on how humans respond to long space flights, with vanishing amounts for non-human exploration research. The Prometheus program of research on new nuclear propulsion technologies would be shelved indefinitely, falling from \$270 million last year to just \$9 million in 2007 because of budget constraints.

The Science portfolio of earth observations, astronomy, and robotic exploration of the solar system and universe would be protected overall from cuts in the 2007 budget, but the 2006 funding level is already well below the 2005 budget after transfers to the space craft development programs. Still, even with a flat budget there would continue to be difficult choices and program terminations because of dramatic reductions from previous NASA plans. **The total Science portfolio of \$5.3 billion (up 1.5 percent) would be a small increase, but would be down \$600 million from NASA's projections as recently as last year, forcing cuts to many missions.** Science is divided into the three themes of Solar System Exploration (SSE), the Universe, and the Earth-Sun System (see Table II-12). Funding for all three themes would be flat or slightly increasing, after sharp cuts in 2006, but even the 2007 budget would contain steep cuts: the astrobiology research portfolio in SSE would be cut in half, work on the Stratospheric Observatory for Infrared Astronomy (SOFIA) project would end abruptly, many space science and earth

science programs would be reduced, missions such as the Terrestrial Planet Finder would be eliminated, and other missions such as the Space Interferometer mission would be delayed. The Explorers program of low-budget spacecraft would be reduced by 20 percent, resulting in no launches at all between 2009 and 2012.

At the same time, some programs would gain, both inside and outside the Science portfolio: funding for the Mars Science Laboratory, planned for launch in 2009, would see its funding surge from \$253 million to \$348 million. Robotic Lunar Exploration funding would double to \$273 million within the Exploration Systems Research and Technology account, with much of the funding going to the Lunar Reconnaissance Orbiter scheduled for launch in 2008. Ballooning development costs would force the James Webb Space Telescope funding to increase 22 percent to \$443 million in Universe, even as the launch date is pushed back to 2013. But these programs would be few and far between in an overall NASA research landscape marked by flat funding or cuts.

Meanwhile, NASA plans to keep construction funding for the International Space Station (ISS) on track in the FY 2007 budget. The ISS budget would rise 3.3 percent to \$1.8 billion; once the Space Shuttle resumes a regular schedule, it is expected to carry Station components into orbit so that construction can resume toward a target completion date of 2010, followed by decommissioning by 2014. But budget constraints would force NASA to further reduce an already minuscule research effort on board the station, and NASA is now seeking other government agencies and the commercial sector to fund research on the station.

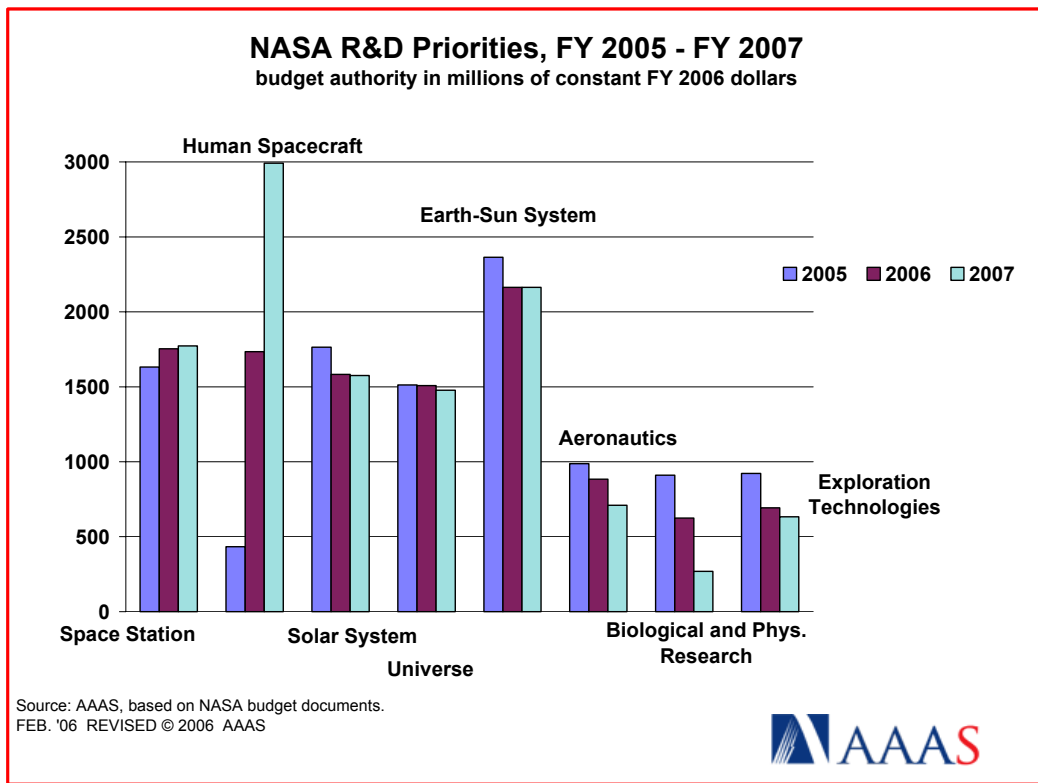


Figure 1. (click on image for PDF)

### Outlook for the NASA Budget

The large increase to NASA’s R&D portfolio in FY 2007 continues a modest upward trend after hitting bottom in 2005 when transfers to the Shuttle program in midyear dramatically reduced R&D funding. NASA’s R&D funding has just barely kept pace with inflation over the past decades, and the 2007 increase would merely recover lost ground (see Figure 2). But excluding the Space Station facilities project and the burgeoning Constellation Systems development effort, **all other NASA R&D would continue to decline**

sharply (see “All Other NASA R&D” and “Aeronautics” in Figure 2), including all of NASA’s support for basic and applied research.

The research cuts in the 2007 budget, coming after cuts in previous years, would further reduce NASA research support across all disciplines. Although much of NASA’s R&D portfolio funds development and facilities projects such as the Space Station, NASA is responsible for 10 percent of all federal support for basic and applied research with far larger roles in key fields. Engineering research makes up the largest part of the NASA portfolio. NASA funds more than a quarter of total federal support for engineering research. NASA supplies nearly all the federal support for some engineering sub-fields such as astronautical engineering and aeronautical engineering. NASA is the leading federal sponsor of the environmental sciences (oceanography, atmospheric sciences, geological sciences), with a third of total federal support. NASA also invests heavily in the physical sciences (astronomy, chemistry, and physics). NASA is the second largest federal sponsor of physical sciences behind the Department of Energy, and is by far the leading sponsor of astronomy research with more than 70 percent of the federal total, but was left out of the American Competitiveness Initiative to boost physical sciences research, as was the Department of Defense, another major sponsor of the physical sciences.

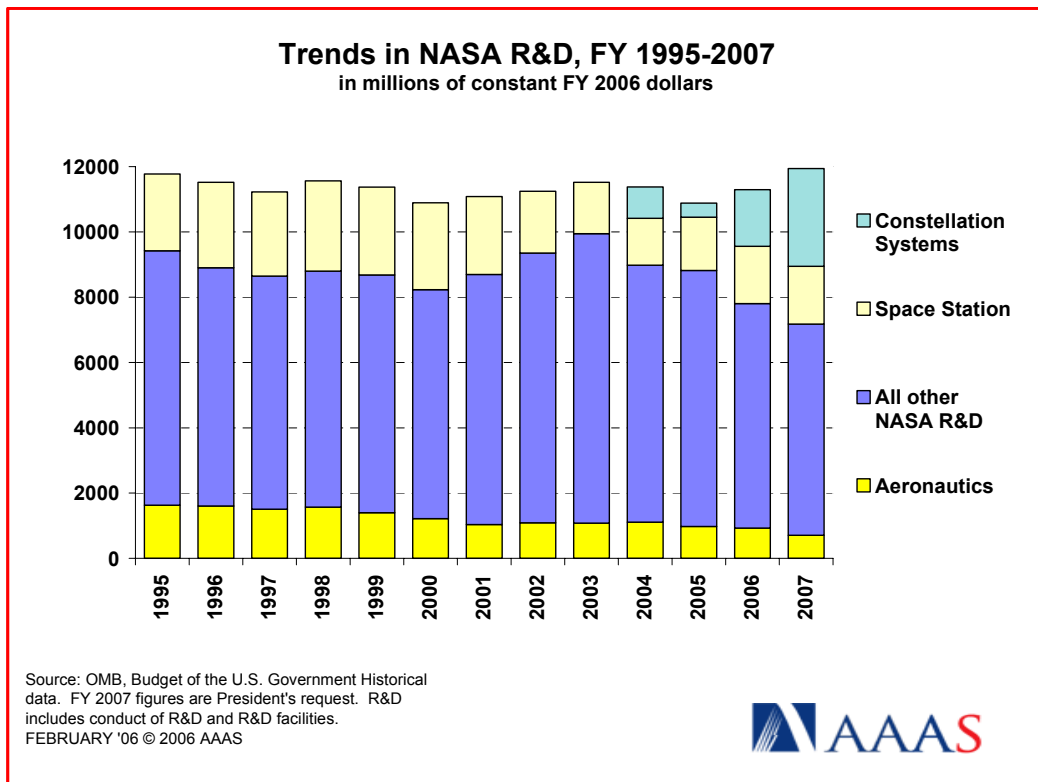


Figure 2. (click on image for PDF)

Because the Vision for Space Exploration remains a high priority even in tough budget times, NASA would receive an increase even as most other domestic agencies face cuts within a declining domestic budget. Looking to the future, the Bush Administration’s outyear budget projections show that in the push to reduce the budget deficit in half over the next few years, funding for most domestic programs would decline each year to 2011, but funding for NASA would continue to increase steadily from \$16.8 billion in 2007 to \$18.5 billion by 2011 for an average increase of 3 percent a year. Funding for the non-R&D Space Shuttle is expected to decline steadily to 2010 and end entirely in 2011, freeing up more money for R&D programs. As a result, the AAAS analysis of the outyear projections in the FY 2007 budget shows NASA R&D growing steadily from \$12.2 billion in FY 2007 to \$13.8 billion in 2010, and then jumping to \$17.8 billion in 2011 after the Shuttle program ends. After adjusting for inflation, NASA R&D could increase 45

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percent over the next five years. But as with the 2007 budget, future budgets would continue to emphasize Constellation Systems, which could further grow from \$3.1 billion next year to a \$7.7 billion program by 2011. The Space Station budget would also increase over the next few years as the project nears completion.

**As a result, funding for Science, Human Systems, Aeronautics, and Education R&D would all lose ground to inflation over the next five years, and Exploration Systems would barely stay flat,** thus signaling continuing cuts in NASA's support for basic and applied research. Although budgets are always determined one year at a time, and Congress has not even acted on the first installment for 2007, Congress has so far been generally supportive of the space exploration vision, even as it wrings its hands over the offsetting cuts in NASA's research portfolio. But without an additional source of funds, appropriators will continue to be hamstrung by tight domestic budget constraints in their attempts to boost NASA research.

(More materials on R&D in the FY 2007 budget, historical data and charts, and more information on *AAAS Report XXXI: Research and Development FY 2007*, can be found on the AAAS R&D Web site at <http://www.aaas.org/spp/rd>.)

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Table II-12. NASA R&amp;D

**Table II-12.** R&D in the National Aeronautics and Space Administration  
(budget authority in millions of dollars)

|   | FY 2005<br>Actual | FY 2006<br>Estimate | FY 2007<br>Budget | Change FY 06-07 |         |
|---|-------------------|---------------------|-------------------|-----------------|---------|
|   |                   |                     |                   | Amount          | Percent |
| <b>Detail of NASA Budget:</b>                         |                   |                     |                   |                 |         |
| <b>1. Exploration Capabilities (EC)</b>               |                   |                     |                   |                 |         |
| <b>Space Operations</b>                               |                   |                     |                   |                 |         |
| International Space Station                           | 1,591             | 1,753               | <b>1,811</b>      | 58              | 3.3%    |
| Space Shuttle *                                       | 5,049             | 4,778               | <b>4,057</b>      | -721            | -15.1%  |
| Space and Flight Support                              | 474               | 339                 | <b>367</b>        | 28              | 8.2%    |
| <b>Total Exploration Capabilities</b>                 | <b>7,114</b>      | <b>6,870</b>        | <b>6,235</b>      | -635            | -9.2%   |
| <b>2. Science, Aeronautics, and Exploration (SAE)</b> |                   |                     |                   |                 |         |
| <b>Science</b>  |                   |                     |                   |                 |         |
| Solar System Exploration:                             |                   |                     |                   |                 |         |
| Discovery   | 183               | 146                 | <b>162</b>        | 16              | 11.0%   |
| New Frontiers   | 211               | 148                 | <b>155</b>        | 7               | 4.6%    |
| Technology  | 129               | 57                  | <b>73</b>         | 16              | 28.0%   |
| Deep Space Mission Sys.                               | 258               | 255                 | <b>247</b>        | -8              | -3.0%   |
| Solar System Research                                 | 351               | 327                 | <b>274</b>        | -53             | -16.2%  |
| Mars Exploration                                      | 588               | 650                 | <b>700</b>        | 50              | 7.7%    |
| <b>Total Solar System Exploration</b>                 | <b>1,721</b>      | <b>1,582</b>        | <b>1,610</b>      | 28              | 1.8%    |
| The Universe:   |                   |                     |                   |                 |         |
| Navigator   | 179               | 146                 | <b>128</b>        | -17             | -12.0%  |
| James Webb Space Telescope                            | 295               | 364                 | <b>443</b>        | 79              | 21.7%   |
| Hubble Space Telescope                                | 303               | 269                 | <b>337</b>        | 68              | 25.4%   |
| SOFIA 1/  | 72                | 48                  | <b>0</b>          | -48             | -100.0% |
| Gamma-Ray Large Area Tel.                             | 111               | 126                 | <b>85</b>         | -41             | -32.2%  |
| Discovery   | 95                | 138                 | <b>101</b>        | -37             | -26.7%  |
| Explorer  | 57                | 85                  | <b>68</b>         | -18             | -20.8%  |
| Universe Research                                     | 322               | 306                 | <b>307</b>        | 1               | 0.3%    |
| Int'l Space Science Collab.                           | 18                | 13                  | <b>20</b>         | 7               | 50.8%   |
| Beyond Einstein                                       | 24                | 14                  | <b>21</b>         | 7               | 50.0%   |
| <b>Total Universe</b>                                 | <b>1,475</b>      | <b>1,508</b>        | <b>1,509</b>      | 1               | 0.1%    |
| Earth-Sun System:                                     |                   |                     |                   |                 |         |
| Earth Systematic Missions                             | 264               | 164                 | <b>302</b>        | 138             | 84.2%   |
| Living with a Star                                    | 201               | 239                 | <b>226</b>        | -13             | -5.4%   |
| Solar Terrestrial Probes                              | 116               | 94                  | <b>84</b>         | -10             | -10.9%  |
| Explorer Program                                      | 149               | 130                 | <b>73</b>         | -57             | -43.5%  |

(continued)

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|                                   | FY 2005<br>Actual | FY 2006<br>Estimate | FY 2007<br>Budget | Change FY 06-07 |         |
|-----------------------------------|-------------------|---------------------|-------------------|-----------------|---------|
|                                   |                   |                     |                   | Amount          | Percent |
| Earth System Sci. Pathfinder      | 111               | 142                 | <b>161</b>        | 20              | 13.8%   |
| Multi-Mission Operations          | 288               | 267                 | <b>265</b>        | -3              | -1.0%   |
| Earth-Sun Research                | 921               | 882                 | <b>878</b>        | -4              | -0.4%   |
| Applied Sciences                  | 82                | 95                  | <b>51</b>         | -44             | -46.2%  |
| Education and Outreach            | 24                | 23                  | <b>23</b>         | 1               | 2.6%    |
| Earth-Sun Technology              | 152               | 127                 | <b>146</b>        | 19              | 14.9%   |
| Total Earth-Sun System            | 2,306             | 2,164               | <b>2,211</b>      | 47              | 2.2%    |
| <b>Total SCIENCE</b>              | 5,502             | 5,254               | <b>5,330</b>      | 76              | 1.5%    |
| <b>Exploration Systems</b>        |                   |                     |                   |                 |         |
| Constellation Systems:            |                   |                     |                   |                 |         |
| Crew Exploration Vehicle          | 54                | 839                 | <b>895</b>        | 56              | 6.6%    |
| Crew Launch Vehicle               | 11                | 384                 | <b>837</b>        | 453             | 117.8%  |
| ISS Cargo Crew Services           | 0                 | 51                  | <b>191</b>        | 140             | 272.5%  |
| Launch and Mission Sys.           | 0                 | 134                 | <b>470</b>        | 336             | 250.7%  |
| Exploration Commun. & Navig.      | 0                 | 51                  | <b>103</b>        | 52              | 103.4%  |
| Other Constellation Sys.          | 358               | 274                 | <b>563</b>        | 288             | 105.1%  |
| Total Constellation Systems       | 422               | 1,734               | <b>3,058</b>      | 1,324           | 76.4%   |
| Exploration Systems Res. & Tech.: |                   |                     |                   |                 |         |
| Centennial Challenges             | 10                | 0                   | <b>10</b>         | 10              | --      |
| Robotic Lunar Exploration         | 52                | 134                 | <b>273</b>        | 138             | 103.1%  |
| Prometheus Nuclear Propul.        | 270               | 76                  | <b>9</b>          | -66             | -87.6%  |
| Exploration Tech. Development     | 478               | 482                 | <b>354</b>        | -128            | -26.6%  |
| Hubble Servicing Mission          | 89                | 0                   | <b>0</b>          | 0               | --      |
| Total Exploration Systems R&T     | 899               | 693                 | <b>646</b>        | -46             | -6.7%   |
| Human Systems Res. & Tech.:       |                   |                     |                   |                 |         |
| Life Support & Habitation         | 309               | 209                 | <b>103</b>        | -107            | -50.9%  |
| Human Health & Perf.              | 337               | 257                 | <b>156</b>        | -101            | -39.3%  |
| Human Sys. Integration            | 243               | 157                 | <b>16</b>         | -142            | -90.1%  |
| Total Human Systems R&T           | 888               | 624                 | <b>275</b>        | -350            | -56.0%  |
| <b>Total EXPLORATION SYSTEMS</b>  | 2,209             | 3,050               | <b>3,978</b>      | 928             | 30.4%   |
| <b>Aeronautics Research</b>       | 962               | 884                 | <b>724</b>        | -160            | -18.1%  |

(continued)

Table II-12. NASA R&D

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|                                      | FY 2005<br>Actual | FY 2006<br>Estimate | FY 2007<br>Budget    | Change FY 06-07 |               |
|--------------------------------------|-------------------|---------------------|----------------------|-----------------|---------------|
|                                      |                   |                     |                      | Amount          | Percent       |
| <b>Cross-Agency Support Programs</b> |                   |                     |                      |                 |               |
| Education                            | 179               | 162                 | <b>153</b>           | -9              | -5.6%         |
| Advanced business systems            | 0                 | 156                 | <b>108</b>           | -48             | -30.8%        |
| Innovative Partnerships              | 199               | 215                 | <b>198</b>           | -17             | -7.9%         |
| Shared Capabilities                  | 0                 | 0                   | <b>32</b>            | 32              | --            |
| <b>Total CROSS-AGCY. SUPPORT</b>     | <b>378</b>        | <b>534</b>          | <b>492</b>           | -42             | -7.8%         |
| <b>Total SAE</b>                     | <b>9,051</b>      | <b>9,721</b>        | <b>10,524</b>        | 803             | 8.3%          |
| 3. Inspector General (non-R&D)       | 31                | 32                  | <b>34</b>            | 2               | 4.7%          |
| <b>TOTAL NASA Budget</b>             | <b>16,196</b>     | <b>16,623</b>       | <b>16,792</b>        | 169             | 1.0%          |
| <i>minus non-R&amp;D activities:</i> |                   |                     |                      |                 |               |
| <i>Space Shuttle</i>                 | <i>-5,049</i>     | <i>-4,778</i>       | <i><b>-4,057</b></i> | <i>-721</i>     | <i>-15.1%</i> |
| <i>Other non-R&amp;D</i>             | <i>-474</i>       | <i>-495</i>         | <i><b>-475</b></i>   | <i>-20</i>      | <i>-4.1%</i>  |
| <i>Inspector General</i>             | <i>-31</i>        | <i>-32</i>          | <i><b>-34</b></i>    | <i>2</i>        | <i>4.7%</i>   |
| <i>Education &amp; Training</i>      | <i>-24</i>        | <i>-24</i>          | <i><b>-25</b></i>    | <i>2</i>        | <i>6.7%</i>   |
| <b>TOTAL NASA R&amp;D</b>            | <b>10,618</b>     | <b>11,295</b>       | <b>12,202</b>        | 907             | 8.0%          |

Source: OMB R&D data for FY 2007, agency budget justification, and agency documents.

All figures are rounded to the nearest million. Changes calculated from unrounded figures.

**NASA has proposed to restructure its accounts in FY 2007.**

**Figures for all years have been adjusted to reflect the proposed structure.**

**FY 2005 figures are based on the September 2005 operating plan;**

**FY 2006 figures are based on the January 2006 operating plan.**

\* FY 2005 and 2006 Shuttle figures include emergency supplementals for hurricane damages.

1/ Stratospheric Observatory for Infrared Astronomy

2/ Formerly Biological and Physical Research.

**Please see Chapter 10 for a discussion of NASA R&D.**

**REVISED February 16, 2006**