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SPACE STUDIES BOARD BULLETIN

FROM THE CHAIR

This is a time for anticipation. The President's FY2007 budget request for NASA should have been settled by now between NASA and OMB, but the outcome and the profound implications for the future of the space program will not be known until early February. It is no secret that NASA will not receive the funding that is required to pursue all the tasks assigned to it. The issues are how this funding will be distributed; where will the funding be adequate for progress; and where are there to be setbacks and damage?

NASA's Administrator, Mike Griffin, has embraced a broad spectrum of goals for NASA. This is a welcome change from a year ago when NASA invoked a prioritization that focused on a very narrow interpretation of the Vision for Exploration outlined by President Bush in his speech of January 14, 2004. NASA indeed has many goals. Its task is nothing short of exploring the universe, extending the human presence into the solar system, and fully utilizing the opportunities of space for humankind.

Mike Griffin also has introduced the concept of balance in the NASA program, a term that was previously banned from the NASA lexicon. We can conceive of balance between human space exploration and robotic science and also balance among the disciplines within the science directorate. This is balance in the sense of optimization, not entitlement. For NASA's many tasks, the issue is how to optimize the available resources so that reasonable progress can be made across the board.

One wonders, however, whether there is an adequate appreciation in NASA and OMB, and in the Congress, concerning how many different goals of NASA there are—progress in human exploration and progress in science; short-term tactics and long-term strategy—that need to be optimized. Or whether optimization is in fact even possible within the highly constrained overall resources.

Administrator Griffin has said consistently that science will not be asked to pay for human exploration of space. This statement requires some translation. The Science Mission Directorate (SMD), which includes Earth and space science, has so far not been asked to pay for human exploration. However, life and microgravity sciences, which reside in the Exploration Systems Mission Directorate, have seen their program scaled back drastically, presumably to provide, in part, the limited resources that are needed to begin the development of the Crew Exploration Vehicle. NASA has a stated goal, which is understandable, to achieve some traction in the next few years towards the President's directive to return to the Moon, and the funds need to come from somewhere. However, there is a trade-off to be made here. No one doubts that a vibrant research program in life and microgravity sciences will be necessary to achieve the long-term goal of extending the human presence into the solar system. The long-term strategic necessity is being traded off against the near-term requirement for money.

Griffin has not said that SMD will be excused from helping to pay for the return to flight of the Shuttle and the completion of the International Space Station (ISS). In fact, in a letter to OMB [posted on the internet], he offered to cap the SMD budget at the FY2006 level for five years, thereby freeing up funds for the continuing assembly of the ISS with the Space Shuttle until the Shuttle's retirement in 2010. It is unusual to have insight into the budget negotiations between NASA and OMB, and whether this

(Continued on page 2)

INSIDE THIS ISSUE

FROM THE CHAIR

(continued from page 1)

was a ploy that ultimately will not result in a drastic cut for science will not be known until the FY2007 budget is released. However, the magnitude of this potential cut is staggering. It would effectively eliminate $4 billion from the planned SMD program over the next five years. One could argue that SMD should never have expected to achieve the planned growth since it would have resulted in an Earth and space science program that was funded at 38 percent of the NASA budget, compared to the current 33 percent. It will be more reasonable, however, if SMD is allowed to grow in proportion to the overall NASA budget, maintaining its current fair share.

Mary Cleave, the Associate Administrator for SMD, has consistently said that each of the four science disciplines in SMD—astrophysics, heliophysics, solar system exploration, and Earth science—will be treated fairly and asked to solve their own problems within their funding allotments. One wonders, however, how the distribution among the disciplines is to be done? It cannot be based on the allocations made during the initial excesses of the exploration vision, since this greatly favored Mars exploration at the expense of other important science programs; indeed, one of the first acts of Mike Griffin was to rebalance the science program at the expense of the growth in robotic exploration of Mars. The distribution also cannot be based on the pre-exploration vision budget, because at that time Earth science had been in a systematic decline and did not have its reasonable share of the science budget. It's a tough call. One can hope that when the distribution is made NASA will be able to articulate a defendable and acceptable logic.

There is also a question of balance within each science discipline of SMD; between the sizes of flight missions; and among flight programs, Research & Analysis (R&A) and Mission Operations and Data Analysis (MO&DA). NASA likes its big, spectacular programs, its strategic missions, e.g., the upcoming James Webb Space Telescope. In times of limited funding, however, it is questionable whether emphasis on the extravaganzas is the optimum choice. Rather, a balanced program of small, medium, and an occasional large flight program, founded on vibrant R&A and MO&DA programs, is more likely to yield the maximum science for the funding available, which after all should be the goal. This is an issue that demands close cooperation between NASA and the concerned science community to produce the optimum science program. There may be pain in these decisions, but no less than the future of each of the science disciplines is at stake.

We can also ask about the balance between the cost of flight programs and their capabilities. One of the most alarming and discouraging trends in space programs worldwide is the growing disparity between what flight programs were expected to cost and what they actually end up costing. Under these circumstances, it is impossible to plan and optimize the science program. Is the disparity because NASA and industry are simply incompetent estimators or driven to low-balling the estimates to sell the initial program? Is it that we can no longer manage programs effectively? Have we become so risk adverse that we are more concerned with process than with smart, effective engineering? Whatever the reason, this is a problem that needs to be solved if we are to have a future. Ironically, the programs for which cost overruns are minimized are Principal-Investigator class missions, such as the Explorer and Discovery programs, since these are capped to start with and, if needed, are usually descoped to remain within the cap. These are the programs that NASA is threatening to de-emphasize the larger strategic missions.

There is a question also about the balance between NASA centers and the broader space science community, residing mainly in the nation's research universities. NASA is concerned about its workforce; it has excess capacity and underutilized staff at its centers. If the consequence of this concern were to be to continue to gather more scientific research into NASA centers, at the expense of the university researchers, it would be a serious mistake. The scientific talent of the nation in space research does not reside principally at NASA centers. There are only two members of the National Academy of Sciences active at a NASA center compared with more than 100 who would list space research among their primary activities at the nation's universities. NASA centers do have enormous capabilities in engineering and management, as measured by their many members of the National Academy of Engineering. In the beginning of the space program, NASA proactively marshaled the scientific talent residing in universities and depended upon it for technical innovation, instrument development, data analysis, and theoretical advances. It was wise then, and it would be wise again to emphasize this resource.

When balancing present needs, and the tactical decisions required to support them, against long-term strategic requirements, the issue of the future workforce cannot be avoided. The nation's aerospace workforce is aging and needs to be replenished; the growing restrictions imposed by the International Traffic in Arms Regulations (ITAR) regulations are requiring that the future workforce be comprised of U.S. citizens, presumably educated in U.S. universities. Effective engineering and scientific education requires hands-on experience with real space pr ojects. Among our most important issues of balance, then, is the need to worry about the health of the university research community, which will provide this hands-on education and generate the required workforce.

The number of issues that need to be optimized in the NASA budget are many—more even than we have discussed here. One hopes that somewhere in the NASA administration there are individuals who worry about each and every one of these issues and that collectively they have produced an optimized budget that, within the available resources, is the best that can be achieved. And that they are able to articulate and defend the choices they made. We'll have to see in a few weeks.

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GUEST COLUMN

(During the transition period prior to the arrival of the new SSB Director, we've invited SSB Research Associate, Dwayne A. Day, to author a guest column)

A Terrabuck for Mars?

Two years ago President Bush announced a new space policy now known as the Vision for Space Exploration. At the time, numerous newspaper and broadcast media described it as "a trillion dollar humans-to-Mars program." But sending humans to Mars is only one of the distant longer-range goals of the Vision, not the primary goal, and in September, when NASA revealed its architecture for sending humans to the Moon, Administrator Michael Griffin stated that the project would cost $104 billion over the next 15 years. Yet the trillion dollar Mars mission is still occasionally mentioned in various media, most often in editorials attacking NASA programs, particularly during budget time. What are the origins of these claims?

The $1 trillion cost estimate is unfounded. It is based upon an inaccurate reading of historical data and flawed mathematics. It originated in a 2004 Associated Press article that ran a week before Bush's formal announcement. The article stated: "No firm cost estimates have been developed, but informal discussions have put the cost of a Mars expedition at nearly $1 trillion, depending on how ambitious the project was. The cost of a Moon colony, again, would depend on what NASA wants to do on the lunar surface."

The information in the article apparently came from interviews, none of which included government sources, and was based upon memories of historical estimates of human exploration plans rather than available documentation. The AP writer combined the costs of human lunar and Mars missions over a period of decades, adjusted the upper total cost for inflation, and then rounded it up by at least $200 billion.

In 1989 President George H.W. Bush had proposed a Space Exploration Initiative (SEI) that included both a Moon base and a human mission to Mars. NASA initially estimated the total cost for both of these efforts at approximately $400 billion over 30 years. The cost of the Mars mission alone was $172.9 billion, plus $13.85 billion for precursor probes, or a total of $186.75 billion. The lunar base was estimated to cost $209.46 billion. By late 1989, using slightly different baseline assumptions, NASA had produced another cost estimate of $541 billion for 34 years of lunar and Mars operations, also roughly split in half. After this, the media often reported that the costs of Bush's plan were either $400-$500 billion, or $400-$550 billion. Often the press erroneously reported that these costs were for a single mission to Mars, rather than for thirty years or more of operating bases on *both* the Moon and Mars.

The Space Exploration Initiative received no significant funding and was completely dead within three years. But the huge cost estimates acquired a sort of permanence, in part because they were easily accessible via a search of media reports using such tools as the LEXIS/NEXIS search engine. Few people, including reporters, have the inclination to ask whether those media reports themselves were accurate and to search out the original information, which exists in NASA historical archives. In January 2004 an AP writer took the highest cost for both missions, adjusted it for inflation, and then rounded it up to $1 trillion for Mars.

Unfortunately, the cycle then repeated itself. Whereas the 1989 claims ($400-$550 billion) had been repeated numerous times without checking, now the $1 trillion claim was repeated again and again. The $1 trillion figure was repeated in other forums and quoted by politicians and even a few scientists (albeit not anyone actually involved in active space programs). Soon other reporters were quoting the politicians and who were the $1 trillion figure, lending it greater legitimacy, even though they had gotten it from an arguably flawed wire service article.

Another common mistake that occurred in various reports about the human space exploration plan was for reporters and pundits to claim that NASA's later figures estimating the cost of a lunar or Mars plan were illegitimate because they were less than the 1989 figures, even though both sets of figures had been produced by the same agency using substantially different sets of assumptions.

For instance, the 1989 SEI cost estimates assumed an extremely ambitious program that called for a permanent lunar base almost from the start of operations. The estimates projected costs not only for the initial goals, but also for decades of operations. In addition, NASA no longer operates in the same ways as it did in 1989. As an example, the 1989 cost estimates assumed that robotic Mars missions preceding human flights would have used expensive Titan 4 rockets and the spacecraft themselves would have been expensive, in the billion-dollar range. However, NASA switched its Mars and other planetary missions to cheaper Delta 2 rockets in the 1990s and adopted an approach where missions cost less than half the billion-dollar missions proposed in the late 1980s. Some of the projects proposed for the Space Exploration Initiative have already been accomplished and do not need to be done again. In addition, all SEI transportation costs were based upon using the space shuttle and shuttle-derived launch vehicles rather than cheaper alternatives. Simply put, the 1989 estimates are not applicable to the way that NASA expects to operate in the twenty-first century and therefore should not be used as a baseline for future plans.

This is not to say that NASA cost estimates are reliable. The Congressional Budget Office reported in September 2004 that, historically, NASA spaceflight projects cost 45 percent more than the agency has estimated. It turns out that this is essentially the same as for Department of Defense programs. Air Force space programs regularly cost 69 percent more than estimated. Missile defense programs also overrun their estimates by 69 percent. Fixed-wing aircraft cost 42 percent more than estimated and military ground vehicles—not exactly the most high-tech or weight-constrained hardware procured by the U.S. government—have historically overrun their cost estimates by 71 percent. NASA's estimates are therefore not unusual for federal procurement programs.

All of this is further proof of the old axiom that those who fail to learn from history are probably failing economics as well.

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BOARD AND COMMITTEE NEWS

- The **Space Studies Board** (SSB) held its 147th meeting at the National Academies' Beckman Center in Irvine, CA, on November 8-10, 2005. One major topic for the meeting was the status of NASA's human space exploration planning and related plans for research on the International Space Station (ISS). Peter Alf and Carl Walz of the Exploration Systems Mission Directorate (ESMD) briefed the board on NASA's ISS utilization requirements analysis process, the results of that analysis, and subsequent planning for research on the ISS. Later in the meeting Doug Cooke, deputy associate administrator of ESMD, put the former material in context during a joint SSB-Aeronautics and Space Engineering Board video-conference briefing summarizing the results of the NASA's recent exploration systems architecture study. In separate briefings, Eric Smith of NASA Headquarters and John Mather of the Goddard Space Flight Center reported on progress and future plans for development of the James Webb Space Telescope.

The board addressed international aspects of space research with a briefing on current European Space Science Committee (ESSC) activities and the status of European Space Agency planning for space exploration from Gerhard Haerandel, ESSC chair, and a briefing on the Chinese space program from Marcia Smith, Congressional Research Service. Smith also provided a summary on current congressional attention to the U.S. space program. The remaining meeting time was devoted to reviewing the status of selected ongoing SSB studies, planning near-term consultations with government officials regarding potential future studies, considering membership rotations in 2006, and planning the next SSB meeting. The board will meet next at the National Academies' Keck Center in Washington, DC on March 6-8, 2006.

- The **Committee on Astronomy and Astrophysics** (CAA) met November 29-30, 2005, at the National Academies' Beckman Center in Irvine, CA. The committee's agenda on the 29th was largely made up of presentations by officials from NASA and the NASA Centers. The committee asked Charles Elachi (JPL) and Edward Weiler (GSFC) to discuss the astronomy programs at their Centers, and to provide their views on the decadal survey process in astronomy and astrophysics. Anne Kinney (NASA) and Wayne van Citters (NSF) also updated the committee on the activities in the astronomy divisions in their respective agencies. In addition, the committee heard a report from Matt Mountain about the conclusions of the JWST Science Assessment Team, which he led. During the second day of the meeting, the committee briefly discussed the role of NASA's Science Centers with the chair of the SSB's Astronomy Science Centers committee, and spent the rest of the day discussing the presentations from the previous day, as well as issues pertaining to the next decadal survey. The committee plans to meet this spring in Washington, DC.

- The **Committee on Planetary and Lunar Exploration** (COMPLEX) met on November 2-4, 2005 at the National Academies' Beckman Center in Irvine, CA. The meeting was devoted to updates on relevant NASA planetary activities and to finalizing draft plans for committee activities over the next 5 years. On December 9, 2005, the committee's proposal for a lunar science strategy was redrafted in response to an informal expression of interest by NASA. Additionally, NASA's Mars Program Director expressed interest in having the committee assess the new Mars exploration architecture. It now seems likely that a lunar science study will be initiated in the early part of 2006 by an ad hoc group derived from COMPLEX and the SSB's other standing space science committees.

The next meeting of the committee will be held on March 29-31, 2006, at the National Academies' Keck Center in Washington, DC.

- The **Task Group on Organic Environments in the Solar System** (TGOESS) did not meet this quarter. Work on revising the report in response to Reviewers comments is nearing completion.

- The **Committee on the Limits of Organic Life** (LIMITS) did not meet this quarter. The committee is currently engaged in drafting the text of its final report, which is anticipated to enter the NRC's external review process in the first quarter of 2006. Publication of the committee's report is expected in the summer of 2006.

- The **Committee on the Origins and Evolution of Life** (COEL) held its final meeting of the year in October 3-5, 2005 in Boulder, CO. The meeting was devoted to planning COEL's forthcoming Mars Astrobiology Strategy, a project that will undertaken by an ad hoc group derived from COEL. COEL's new co-chair, Bruce Jakosky, presided and 3 of 6 new members were present. On December 7, 2005, the appointment of COEL's other co-chair, Kenneth Nealson, was approved. COEL's next meeting will take place at the National Academies' Beckman Center in Irvine, CA, on January 23-25, 2006.

- The **Committee on Priorities for Space Science Enabled by Nuclear Power and Propulsion** (NUCLEAR) completed its work in the summer of 2005, and the report's executive summary and other front matter were released in August. The complete text of the full report is scheduled for release in the first quarter of 2006.

- Advanced planning for the **Committee on the Astrobiology Strategy for the Exploration of Mars** (MARS) started at COEL's October meeting, and the committee is awaiting final approval of membership appointments. The group will meet four times in 2006, with the first meeting planned for January 23-25, 2006 at the National Academies' Beckman Center in Irvine, CA.

- The **Committee on Planetary Protection Requirements for Venus Missions** (VENUS) held its one and only meeting in conjunction with COEL's October 3-5, 2005, meeting in Boulder. A draft of the letter report on planetary protection requirements for Venus missions was completed in late October and sent to external reviewers on November 2, 2005. The text has been revised in response to reviewer comments and is awaiting final sign-off. The committee held a conference call with chair, Jack Szostak, on December 14, 2005.

- Approximately half of the members of the **Committee on Solar and Space Physics** (CSSP) participated in a workshop, "Solar and Space Physics and the Vision for Space Exploration," that was organized by the committee and NASA. The workshop, which was held on October 16-20, 2005, at a conference facility in Wintergreen, VA, brought together over 100 members of the space science, planetary science, radiation physics, space flight operations, and exploration engineering communities in order to:

- Increase awareness and understanding of the complex array of solar and space physics issues pertinent to the environments of the Earth, Moon, and Mars;
- Identify compelling research goals necessary to ensure the success of the Vision for Space Exploration in these environments;
- Discuss the directions that research in these fields should take over the coming decades in order to achieve these goals.

A particular emphasis of the workshop was on improving predictions of solar energetic particle storms, the solar eruptions that produce them, and the impact of solar storms on the Earth, Moon, and Mars environment. A workshop report is anticipated by early summer 2006. Further information about the workshop is available at: http://hesperia.gsfc.nasa.gov/sspvse/.

At the end of this reporting period, the CSSP had also completed its response to external review for the report on the workshop on "Distributed Arrays of Small Instruments (DASI) for Solar-Terrestrial Research." Final, published copies of this report are expected early in 2006.

- The **Committee on Earth Studies** continues to stand down as work progresses on the decadal study, "Earth Science and Applications from Space: A Community Assessment and Strategy for the Future." However, the committee did complete and publish the report, *Extending the Effective Lifetimes of Earth Observing Research Missions* (see condensed executive summary on page 6 of this newsletter). This report, which was requested by NASA,

(1) Evaluates the effectiveness of the mission extension paradigm as a means for managing mission life-cycles,
(2) Assesses whether the NASA Senior Review process provides an appropriate foundation to implement an Earth science mission extension process, and
(3) Identifies modifications to the Senior Review process that could enhance its value to Earth science missions.

- The study, **Earth Science and Applications from Space: A Community Assessment and Strategy for the Future,** is led by a steering committee and seven thematically organized study panels. During the quarter, the steering committee and each of the panels met once, as follows:
  - ESAS Steering Committee: October 25-26, 2005 (Washington, DC)
  - Earth Science Applications and Societal Benefits: October 31-November 1, 2005 (Washington, DC)
  - Land-use Change, Ecosystem Dynamics and Biodiversity: November 17-18, 2005 (Washington, DC)
  - Weather (incl. space weather and chemical weather): November 11-12, 2005 (Woods Hole, MA)
  - Climate Variability and Change: October 24-26, 2005 (Washington, DC)
  - Water Resources and the Global Hydrologic Cycle: November 14-15, 2005 (Seattle, WA)
  - Human Health and Security: December 1-2, 2005 (Washington, DC)
  - Solid-Earth Hazards, Resources, and Dynamics: November 17-18, 2005 (Washington, DC)

In addition, the steering committee and the panels held numerous teleconferences. Members of the Earth Science Applications and Societal Benefits panel also attended most of the meetings of the other panels. The next meeting of the steering committee is January 10-12, 2006 in Washington, DC. Those panels that have not already held their third and final meeting will do so during January and February.

Representatives from the survey steering committee and the panels were present on December 6, 2005, for a well-attended "town hall" community forum, which was held in conjunction with the fall meeting of the American Geophysical Union. Copies of the steering committee and panel presentations are available on the survey's public website at http://qp.nas.edu/decadalsurvey. A town hall event is planned for January 30, 2006, at the annual meeting of the American Meteorological Society.

The final report from the steering committee, which will include a prioritized list of potential activities to advance Earth science and applications from space, is expected in late 2006.

- The **Committee on Space Biology and Medicine** (CSBM) was not active during this period, except for various tracking and dissemination activities such as providing requested materials and information on prior reports or assistance to related studies by other committees.
- The **Committee on Microgravity Research** (CMGR) was not active during this period, except for various tracking and dissemination activities such as providing requested materials and information on prior reports.
- The SSB, working jointly with the **Aeronautics and Space Engineering Board** (ASEB), organized independent reviews of strategic road maps that were developed by NASA's Advanced Planning and Integration Office. The **NASA Strategic Roadmaps: Science Panel** delivered its report to NASA in prepublication form on August 2, 2005, and this report is currently being edited for a final printing. The second panel, the **NASA Strategic Roadmaps: Space Station Panel,** met on October 3-5 in Washington, DC. At that meeting the panel heard briefings from various NASA officials regarding potential NASA plans relevant to the completion of the International Space Station and its utilization for research to support human exploration. The panel began drafting its report at that meeting and completed it in the weeks that followed. The report, *Review of NASA Plans for the International Space Station*, was delivered to NASA on November 22 and released in pre-publication form the following week (see condensed executive summary on page 7 of this newsletter). The report is being edited for final release, which expected in March 2006.
- The **Committee on Preventing the Forward Contamination of Mars** (PREVCOM) issued a pre-publication version of its report, *Preventing the Forward Contamination of Mars* in July 2005. The report is being prepared for final publication. Committee members David Paige, John Niehoff, and Margaret Race presented the results of the report to the Mars Exploration Program Analysis Group (MEPAG) in November 2005. Dr. Paige will also present the report to the NRC Committee on the Origins and Evolution of Life (COEL) at its upcoming meeting in January 2006.

- The **Committee on Principal Investigator-Led Missions** (COMPILED) completed its report, and committee chair Janet Luhmann briefed the NASA Science Mission Directorate's Associate Administrator and Deputy Associate Administrator, as well as other NASA managers, on the results of the study on December 15. Malcolm Peterson presented the results of the concurrent National Academy of Public Administration (NAPA) report at the meeting. The NRC and NAPA collaborated on their studies. A pre-publication version of the NRC report was released to the public on December 16, 2005, (see condensed executive summary on page 9 of this newsletter).
- The SSB, in cooperation with ASEB, began work on a study on **Large Optical Systems in Space**, which will consider enabling technologies, infrastructure, workforce, and opportunities for interagency synergies to enable future optical systems in space. NASA, a sponsor of the project, has suggested revisions to the statement of task. Further work on developing a study committee will resume once agreement on the study tasks and scope are finalized.
- The **Committee on Astronomy Science Centers** is reviewing lessons learned from experience with NASA's ensemble of space astronomy science centers in order to recommend a set of guiding principles and best practices for consideration in making decisions about approaches to meeting the needs of the astronomy community with future science centers. On October 26-27, 2005, committee chair, Stephen Bohlen, and study director, Pam Whitney, conducted site visits at four astronomy science centers in the Washington, DC area: NASA Goddard High Energy Astrophysics Science and Research Center, the XMM Guest Observer Center, the RXTE Guest Observer Facility and Science Operations Center, and the Space Telescope Science Institute. The committee held its second meeting on November 18-19, 2005, in Washington, DC Matthew Mountain made a presentation on the perspectives of the Space Telescope Science Institute. Committee members heard panel discussions on Science Center User Perspectives (J. Bregman, Univ. of Michigan; Frits Paerels, Columbia University; and, Megan Donahue, Michigan State), Archiving and Data Management (Niel Brandt, Princeton; Gordon Richards, JHU; and Megan Donahue, Michigan State), and HEASARC Perspectives (Nicholas White, GSFC High Energy Astrophysics Science Archive Research Center). On the last day of the meeting the committee discussed the report outline, scheduled writing assignments, and due dates. The committee will meet next on February 9-11, 2006, in Washington, DC. The committee expects to produce its final report in late 2006.
- The **Committee on Meeting the Workforce Needs for the National Vision for Space Exploration** has been organized under the auspices of the SSB and the Aeronautics and Space Engineering Board to conduct a study to assess the current and future supply of a qualified U.S. aerospace workforce that will be required to meet the needs of NASA and the larger aerospace science and engineering community in the context of the nation's long-term space exploration vision. The committee will hold a two-day information gathering workshop as a part of its first meeting at the National Academies' Keck Center in Washington, DC, on January 23-25, 2006.
- The **Committee on Space Research** (COSPAR) did not meet during the fourth quarter. Plans are underway for the organization's 36th Scientific Assembly, which will be held in Beijing, China in July 2006. <http://www.cosparhq.org/Meetings/meetings>.

Abstracts for the meeting are due on February 17, 2006 and can be submitted online through the World Wide Web <http://meetings.copernicus.org/cospar2006>.

In March 2006, the COSPAR Program Committee, Editorial Committee, and Bureau will convene for their Spring planning meetings. In addition, COSPAR's new Scientific Advisory Committee, to be chaired by Prof. Lennard A. Fisk of the University of Michigan, will hold its first meeting. The advisory committee was born from COSPAR's strategic visioning exercises held during 2004-2005. Other changes emerging from COSPAR's visioning include efforts to further involve students and young scientists, and increased attention to education.

Extending the Effective Lifetimes of Earth Observing Research Missions

This report by the Committee on Extending the Effective Lifetimes of Earth Observing Research Missions is available in prepublication format online at http://books.nap.edu/catalog/11485.html. The study was staffed by Arthur Charo, Study Director, Catherine A. Gruber, Assistant Editor, and Theresa Fisher, Senior Project Assistant. The following is adapted from the executive summary of the report.

Executive Summary

The Earth science missions of the National Aeronautics and Space Administration (NASA) are routinely planned and funded on the basis of a nominal mission lifetime. If the mission is still functioning at the end of this nominal lifetime, there are often strong scientific and operational reasons for extending it. But the decision to do so and commitment of the needed resources must be weighed against use of the same resources for developing new observational capabilities and research missions.

NASA has recently begun using the Senior Review process, developed for the space sciences, to make decisions on extensions for Earth science missions. Previously, these decisions had been made ad hoc. This report by the National Research Council's Committee on Extending the Effective Lifetimes of Earth Observing Research Missions reviews the current process and provides recommendations for adapting this process to the specific needs of NASA's Earth science missions.

Finding. NASA's mission-extension paradigm for accomplishing research missions—which is based on planning and funding nominal operational lifetimes, with a separate decision process for extending operations when this nominal lifetime is exceeded—is fundamentally sound.

Implementation of the mission-extension paradigm warrants a structured and uniformly applied process that balances the desirability of extending a mission against the feasibility of doing so.

An effective mission-extension process must carefully reconcile the long lead times required for budget planning against the benefits of deciding as late as possible which missions will be extended.

Earth science missions have unique considerations, such as future operational utility and interagency partnerships, that distinguish them from space science missions; these considerations should be explicitly included in a mission-extension decision-making process.

Recommendation. NASA should continue to formally plan and fund research missions on the basis of the mission-extension paradigm, but it should (1) ensure that the unique requirements of Earth science missions are satisfied and (2) investigate alternative approaches to mission life-cycle funding in particular cases.

Finding. The Senior Review, currently used as the basis for all NASA decisions on space and Earth science mission extensions, is a thorough and well-run process, but it does not adequately satisfy the unique considerations of Earth science missions.

Recommendation. NASA should retain the Senior Review process as the foundation for decisions on Earth science mission extensions, but should modify the process to accommodate Earth science's unique considerations.

The evaluation process should be expanded to complement the NASA-only evaluation with a parallel evaluation through which non-NASA partners can provide their assessment of the need for mission extension—the final NASA decision would be made on the basis of input from both paths.

The overall process should be built around a 5-year rolling approach to evaluations (see Figure ES.1), involving incremental evaluations beginning several years in advance of the final decision, so as to increase community visibility and facilitate partner commitments, with a biennial status briefing that includes all potential partners.

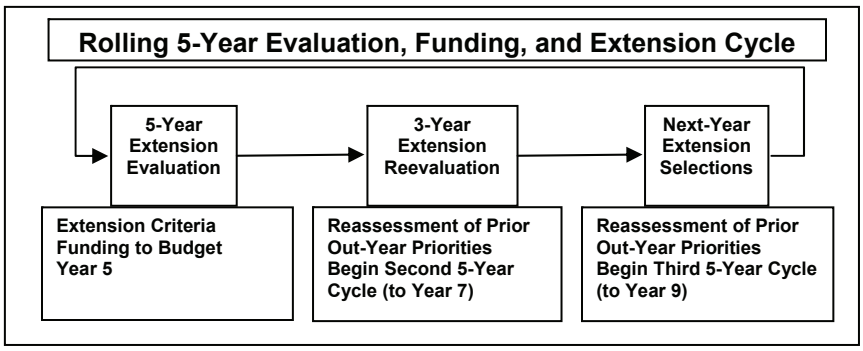

FIGURE ES.1 The rolling-wave planning approach to the mission-extension decision process, as recommended by the committee.

Review of NASA Plans for the International Space Station

This report by the Review of NASA Strategic Roadmaps: Space Station Panel is available in prepublication format online at http://books.nap.edu/catalog/11512.html. The study was staffed by Sandra J. Graham, Study Director, Catherine A. Gruber, Assistant Editor, and Celeste Naylor, Senior Project Assistant. The following is adapted from the executive summary of the report.

Executive Summary

This report of the NRC's Space Station Panel reviews NASA plans for the completion of the International Space Station (ISS) and its utilization in support of the human exploration of the solar system. At the time this report was written, no single integrated plan for the ISS was available for the panel's review. Instead, from the information made available to it from several recent NASA planning activities relevant to ISS utilization for the new Exploration Missions, the panel developed broad advice on programmatic issues that NASA is likely to face as it attempts to develop an updated utilization plan for ISS. The panel also discussed some potentially important research and testbed activities to support exploration objectives that may have to be carried out on the ISS to be successful.

Current Status of ISS Plans

According to the information presented to the panel, the ISS today is approximately 50 percent completed. NASA plans 18 or 19 more flights to finish construction of ISS but hopes to reduce that number. The shuttle, currently the only transportation system capable of deploying the large ISS structural components and research modules, is planned to be decommissioned at the end of 2010. The panel's understanding is that NASA still plans to deploy all previously planned rack-level research facilities except for those associated with the Centrifuge Accommodations Module (i.e., the life sciences glovebox and animal holding

racks). However, it appears that much of their supporting equipment has been eliminated in concert with the NASA research programs that would have utilized them. ISS currently carries a reduced crew of two, and NASA is considering scenarios for increasing it to six in 2009 or 2015, with 2008 being the earliest date that ISS might be capable of sustaining a crew of six.

NASA currently defines the mission objectives for ISS in support of extended manned exploration of space as follows:

- Develop and test technologies for exploration spacecraft systems,
- Develop techniques to maintain crew health and performance on missions beyond low Earth orbit (LEO), and
- Gain operational experience that can be applied to exploration missions.

The panel agrees that these are appropriate and necessary roles for the ISS. However, the panel noted with concern that these objectives no longer include the fundamental biological and physical research that had been a major focus of ISS planning since its inception. In addition to increasing fundamental scientific understanding, much of that research was intended to have eventual terrestrial applications in medicine and industry. Previous NRC reports also emphasized the importance of fundamental biological and microgravity research for the development of new technologies and the mitigation of space-induced risks to human health and performance both during and after long-term spaceflight. The loss of these programs is likely to limit or impede the development of such technologies and of physiological and psychological countermeasures, and the panel notes that once lost, neither the necessary research infrastructures nor the necessary communities of scientific investigators can survive or be easily replaced.

Biomedical and Technology Research

Although it seems unlikely that ISS needs to play a critical research role in support of lunar sorties, the panel concluded that it provides an essential platform for research and technology testing in support of long-term human exploration, including lunar outpost missions and, most especially, the human exploration of Mars. Indeed, it is uncertain whether the risks involved in sending humans on long-term exploration missions can be mitigated to acceptable levels without precursor experimentation and testing aboard the ISS. Understanding cumulative biological and psychological effects in long-term space environments and the impact of microgravity on the physical phenomena on which spacecraft systems depend, as well as long-term verification of hardware and biological countermeasures and life-cycle testing, will all require ISS as the only capability available to tend experiments in a free-fall environment for periods of time that approximate the duration of a Mars outpost class mission.

Without a single defined research plan for ISS, the panel could not verify that specific areas identified by the panel as critical were in fact gaps in NASA's current planning. However, a number of broad areas of research important to exploration were identified in past studies, and this report discusses several of these as examples of research and testing that may prove critical to NASA exploration goals. As described in the report, these priority areas of research on the ISS include:

- Effects of radiation on biological systems,
- Loss of bone and muscle mass during spaceflight,
- Psychosocial and behavioral risks of long-term space missions,
- Individual variability in mitigating a medical/biological risk,
- Fire safety aboard spacecraft, and
- Multi-phase flow and heat transfer issues in space technology operations.

This list is by no means comprehensive and includes at least some areas that have been considered, if not necessarily implemented, in one more of the NASA ISS planning studies reviewed by the panel.

Programmatic Issues

Incomplete Information in Decision Support Tools

The panel noted that risk-based criteria are conspicuously missing from inclusion in the decision support tools presented to the panel. This weakness is particularly troubling in light of the need to prioritize what work can and must to be done with respect to time limitations and other resource-limitations such as cost, crew time, and so forth.

Recommendation: As has been discussed in other reports the characterization of risk should be clearly communicated, along with concrete go/no-go criteria for missions, so as to achieve a rational and supportable prioritization of resource allocation.

Using the ISS to Support Exploration Missions

The panel saw no evidence of an integrated resource utilization plan for use of the ISS in support of the Exploration Missions. Presentations that covered some elements of criteria and processes for determining priorities for utilization of ISS for different exploration missions demonstrated poor definition of those criteria and processes. In particular, the materials presented to the panel did not seem to take into account the effects that high priorities assigned to one mission would have on factors such as the ability to complete another, perhaps later mission, through depletion of necessary resources or limitation of necessary lead times.

Recommendation: NASA should develop an agency-wide, integrated utilization plan for all ISS activities as soon as possible. Such a planning effort should encompass explicitly the full development of ESAS Technology requirements, migration of current ISS payloads to meet those requirements, identification of remaining gaps unfilled by current ISS payloads, and the R&D and technology or operations payloads needed to fill those gaps. An iterative process that includes Exploration Systems Mission Directorate stakeholders and the external scientific and technical community should be employed to assure that the "as flown" experiments closely match the integrated ISS utilization plan.

Recommendation: A scheduled periodic review of the plan with participation of a wide group of stakeholders (e.g., internal and external, scientific and operations) is needed to validate that the plans are still appropriate and that they still produce an integrated approach to attaining the ultimate program goals.

Including Research and Development as an ISS Objective

The ISS represents a unique R&D platform with which to conduct enabling R&D for exploration missions, particularly a Mars mission. Enabling research was not noted as an objective for the ISS support for exploration missions. The panel noted with concern this apparent gap in understanding the value of the ISS for exploration missions. Even in an era of extremely limited resources, for R&D that is necessary to solve exploration problems and reduce crew and missions risks, the ISS may well represent the only timely opportunity to conduct this R&D prior to a Mars mission.

Recommendation: NASA should add a statement of ISS objectives for the exploration mission as follows:

Conduct enabling research as required for

a. Technologies for exploration,
b. Techniques to maintain crew health and performance for missions beyond LEO, and
c. Development of operational capability for long distance flights beyond low earth orbit.

Recommendation: Based on the involvement of a broad base of experts and a rigorous and transparent prioritization process, NASA should develop and maintain a set of research experiments to be conducted aboard the ISS that would enable the full suite of exploration missions. These experiments should be fully integrated into the ISS utilization process.

Planning ISS Utilization to Support Operations Demonstrations for Explorations

The ISS represents a unique platform with which to conduct operational demonstrations in microgravity. For a Mars mission, where significant periods of the mission will occur in microgravity, due to the long travel times enroute to and returning from Mars, the ISS may prove the only facility with which to conduct critical operations demonstrations needed to reduce risks and certify advanced systems. The panel is concerned that no evidence of definition of operations demonstrations requirements for exploration mission was shown, and such requirements do not appear to be a part of the exploration utilization plan for the ISS.

Recommendation: Using a rigorous process based on formal prioritization and involvement of the operations community, NASA should develop and maintain a set of operational demonstrations that need to be conducted on the ISS to validate operational protocol and procedures for long-duration and long-distance missions such as the one to Mars. Integrate these demonstrations into the utilization of ISS to support exploration.

Crew Size

As discussed in previous NRC reports neither time for necessary research and testing, nor the number of available volunteers for human experimentation can be supported by a three person crew, much less the current reduced number of two. Completion of ISS research and testing essential for human missions to Mars and beyond will require a full six person crew to enable astronauts to give adequate time and effort to these activities.

Recommendation: NASA should give top priority to restoring the crew size to at least six members at the earliest possible time, preferably by 2008.

Completion and Support of ISS Research Capability

Given that shuttle flights are being delayed and that each future shuttle flight schedule is unsure, it is possible that the planned ISS configuration will not be completed by 2010, putting the ISS exploration objectives at risk. It appears that there are no plans to provide a back-up alternative to the shuttle launch of ISS structural components and research modules, if the shuttle does not complete this process by 2010.

Recommendation: NASA should plan options and decision points for obtaining a post-shuttle logistics capability for maintaining the ISS facility, for supporting the flight crew and research, and for demonstrating the technology and operations that will enable exploration missions. NASA should establish priorities and develop back up plans to enable the post-2010 deployment of large ISS structural components and the research facilities required to accomplish Exploration Mission objectives.

Principal-Investigator-Led Missions in the Space Sciences

This report by the Committee on Principal-Investigator-Led Missions in the Space Sciences is available in prepublication format online at http://books.nap.edu/catalog/11530.html. The study was staffed by Pamela L. Whitney, Study Director, (SSB) Emilie W. Clemmens, Christine Mirzayan Science and Technology Policy Graduate Fellow, Amanda Sharp, Research Assistant, Catherine Gruber, Assistant Editor, and Carmela J. Chamberlain. Senior Project Assistant, (SSB) The following is adapted from the executive summary of the report.

Executive Summary

Beginning in the early to mid-1990s, NASA moved toward mission lines that offer scientists the opportunity to lead their own space science missions. Before that, scientists had taken responsibility for science instruments and data analysis on a mission, but NASA had managed the projects and developed the spacecraft. NASA first introduced the Discovery Program and developed it into a competitive, peer-reviewed mission line moving toward planetary science exploration under the principal

investigator (PI) mode. Then it transitioned the Explorer Program, the oldest of its competitive mission lines, to the PI-led mode as well. Explorer missions are focused on goals in solar and space physics and in astrophysics; Discovery missions address solar system exploration and astrobiology goals. The PI-led approach gives scientists more autonomy and freedom in the decision making and management of a developing space mission but at the same time enforces a strict cost cap that constrains competition for the selection and subsequent development of the PI-led mission. In the last 5 years, NASA has introduced two additional PI-led mission lines: Mars Scouts for the Mars Exploration Program and New Frontiers for targeted solar system exploration goals.

Thirteen PI-led projects have successfully achieved their mission, and eight others are currently in various stages of development. Two suffered technical failures and one was canceled. In addition, the PI-led mission lines have had to adjust to the changing environment at NASA. Recently, PI-led mission costs and schedules have increased so much that NASA is considering what lessons might be learned from the different PI-led programs and whether the programs can be improved. The Committee on Principal- Investigator-Led Missions in the Space Sciences undertook this task with the understanding that such missions are an essential, scientifically productive component within NASA's suite of missions that complements the strategic missions emerging from the decadal survey and roadmap processes. The vital importance of these small and medium Discovery- and Explorer-class missions was noted in several previous NRC reports, and new input from PIs, project managers (PMs), and others led the committee to the following overall finding:

Finding. The space science community believes that the scientific effectiveness of PI-led missions is largely due to the direct involvement of PIs in shaping the decisions and the mission approach to realizing the proposed science concepts.

In this report the committee recommends practices and incentives for improving the overall conduct of PI-led missions. In particular, it recommends adjustments to the selection and implementation processes that aim to strengthen the mission-line programs so that they can continue to provide one of the best science returns per taxpayer dollar for NASA, the scientific community, and the public. The committee's specific findings and recommendations are presented below.

SELECTION PROCESS

Proposals and Reviews

Finding. The PI-led mission selection process could be made more efficient and effective, minimizing the burden on the proposer and the reviewer and facilitating the selection of concepts that become more uniformly successful projects.

Recommendation 1. NASA should consider modifying the PI-led mission selection process in the following ways:

Revise the required content of the mission proposals to allow informed selection while minimizing the burden on the proposing and reviewing communities by, for example, reconsidering the TMC-lite approach, and eliminating the need for content that restates program requirements or provides detailed descriptions such as schedules that would be better left for postselection concept studies.

Alter the order of the review process by removing low- to medium-ranking science proposals from the competition before the TMC review, and

Allow review panels to further query proposers of the most promising subset of concepts for clarification, as necessary.

Finding. The still-competitive but already funded concept study stage (Phase A) of selected, short-listed PI-led missions is the best stage for the accurate definition of the concept details and cost estimates needed to assist in final selection.

Recommendation 2. NASA should increase the funding for and duration of concept studies (Phase A) to ensure that more accurate information on cost, schedule, and technical readiness is available for final selection of PI-led missions.

Finding. Community-based studies of science opportunities and priorities can be used to focus AO proposals on specific topics of great interest and to guide the choices of selection officials.

Recommendation 3. NASA should make explicit all factors to be considered in the selection of PI-led missions—for example, targets and/or technologies that are especially timely and any factors related to allocating work among institutions and NASA centers.

Proposing Team Experience and Leadership

Finding. The combined relevant experience of the PI and the PMs in PI-led missions is critical to mission success. Programs can emphasize the importance of experience in their selections and create opportunities for prospective PIs and PMs to gain such experience.

Recommendation 4. NASA should develop PI/PM teams whose combined experience and personal commitment to the proposed implementation plan can be evaluated. NASA should also provide opportunities for scientists and engineers to gain practical spaceflight experience before they become involved in PI-led or core NASA missions. These opportunities could become available as a result of revitalizing some smaller flight programs, such as the sounding rocket and University Explorer programs.

Technology Readiness

Finding. As a rule, PI-led missions are too constrained by cost and schedule to comfortably support significant technology development. Those missions that include technology development inevitably have cost and schedule problems.

Regular technology development opportunities managed by PI-led programs could lead to a technology pipeline that would help to enable successful mission selection and implementation.

Recommendation 5. NASA should set aside meaningful levels of regular funding in PI-led programs to sponsor relevant, competed technology development efforts. The results from these program-oriented activities should be made openly available on the program library Web site and in articles published in journals or on the World Wide Web.

FUNDING PROFILES

Finding. Funding profiles represent a special challenge for PI-led missions because they are planned at the mission concept stage with the goals of minimizing costs and achieving schedules. However, like all NASA missions, PI-led missions are subject to the availability of NASA funding, annual NASA budgetary cycles, and agency decisions on funding priorities, all of which can disrupt the planned funding profiles for PI-led missions.

Recommendation 6. NASA and individual mission PIs should mutually agree on a funding profile that will support mission development and execution as efficiently as possible. If NASA must later deviate from that profile, the mission cost cap should be adjusted upward to cover the cost of the inefficiency that results from the change in funding profile (see Recommendation 10.)

INTERNATIONAL CONTRIBUTIONS

Finding. International contributions have an important positive impact on the science capabilities of PI-led missions but are faced with an increasingly discouraging environment, in part due to ITAR. In addition, logistical difficulties associated with foreign government budgetary commitments and the timing of proposals and selections persist. The result is both real and perceived barriers to teaming and higher perceived risk for missions including international partners.

Recommendation 7. NASA PI-led-mission program officials should use recent experiences with ITAR to clarify for proposers (in the AO) and for selected projects (e.g,, in guidance on writing technical assistance agreements and transferal letters) the appropriate application of ITAR rules and regulations.

PROGRAM MANAGEMENT

Role of the Program Office

Finding. The PI-led program offices can play a critical positive role in the success of PI-led missions if they are appropriately located and staffed, and are able to offer enabling infrastructure for projects and NASA Headquarters from the proposal through the implementation stages.

Recommendation 8. NASA should ensure stability at its program offices, while providing sufficient personnel and authority to enable their effectiveness, both in supporting their missions and in reporting to and planning with NASA Headquarters.

Program Oversight Practices

Finding. NASA oversight of PI-led missions, as well as of all missions, increased following a string of mission failures in the late 1990s and is again increasing following the Columbia shuttle disaster. Some of the added oversight, and especially the style of that oversight, appears excessive for robotic missions as small as the PI-led missions. Increases in oversight also strain project resources and personnel to the point of adding risk rather than reducing it.

Recommendation 9. NASA should resist increasing PI-led mission technical and oversight requirements¾as for example, on quality assurance, documentation, ITA-imposed requirements, or the use of independent reviews¾to the level of requirements for larger core missions and should select missions whose risks are well understood and that have plans for adequate and effective testing.

Finding. There is confusion about the processes in place for adjusting PI-led mission cost caps and schedules to accommodate oversight requirements introduced after selection.

Recommendation 10. NASA should clarify the change-of-scope procedures available for projects to negotiate the cost and schedule impacts of any changes in requirements initiated by NASA Headquarters or a PI-led program office, including the addition of reviews, documentation, reporting, and/or increased standards. The schedule impact of negotiating changes of scope should also be evaluated.

Threat of Cancellation

Finding. The threat of cancellation in a termination review is no longer an effective way of keeping PI-led missions within their cost caps, because few missions have been canceled as a result of exceeding their cost caps. Nevertheless, a termination review is taken seriously because it reflects negatively on project management performance and raises the possibility of science descopes. Project leaders need to be made aware of problems that lead to termination reviews so that they can avoid them.

Recommendation 11. NASA should continue to use the existing termination review process to decide the fate of PI-led missions that exceed their cost cap. It should develop lessons learned from termination reviews and make them available to other PI-led projects.

Finding. High-impact decisions such as descopes made by NASA outside the termination review process undermine a PI's authority and can cause a mission to lose science capability.

Recommendation 12. NASA should not descope mission capabilities (including science instruments) without the PI's agreement or outside the termination review process.

PROJECT MANAGEMENT

Technical and Programmatic Failures

Finding. Lessons learned from experience in both PI-led and other missions can be extremely valuable for reducing risk and inspiring ideas about how to do things better. Much useful lessons-learned documentation is available on the Web but is not collected in a coherent library or directory. A modest effort by the program offices to locate these distributed documents, provide a centralized Web site containing links, and advertise its existence would allow these lessons to be more widely used.

Recommendation 13. NASA PI-led program officials and PI-led mission teams should study lessons-learned documentation to benefit from the experiences of previous PI-led missions. NASA should make such lessons learned easily and widely available and update them continuously, as is done on the Discovery Program Web site posted by the Langley Research Center.

Team Interactions

Finding. The leaders of PI-led missions occasionally find they must replace a manager or a key team member to reach their goals. While the cost and schedule impacts of such a major change must be considered, a change in project management needs to be allowed if it is for the good of the mission. The PI should make all final decisions on project management personnel.

Recommendation 14. NASA and the PIs should include language in their contracts that acknowledges the PI's authority to make the final decisions on key project personnel.

Cost, Schedule, and Science Performance

Finding. The summary cost and schedule performance records for PI-led and other missions are not kept in a consistent way, making external comparative analyses difficult. Science activities on PI-led missions seem to be competitive with those on core missions to the extent that the data sets are made available and science analysis is supported.

Recommendation 15. NASA should maintain and make available for assessment consistent and official documentation of project costs and reasons for cost growth on all PI-led (and other) missions.

FROM OUR STAFF

Tanja E. Pilzak is the new Administrative Coordinator for SSB. She comes to SSB from the Division on Earth and Life Studies (DELS) where she was a research associate for 5 years in the Board on Earth Sciences and Resources (BESR) and the Board on Agriculture and Natural Resources (BANR). Prior to becoming a research associate, Tanja was in the Office of Contracts and Grants for 3 years as a proposal specialist and a contract assistant. She holds an M.S. in environmental management from the University of Maryland University College and a B.S. in natural resources management from the University of Maryland College Park.

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