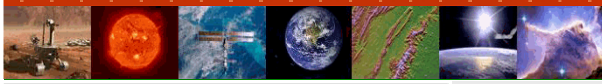
SPACE STUDIES BOARD NEWS



APRIL—JUNE 2006

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SSB CALENDAR

Review of NASA Science Mission Directorate Science Plan **Washington, DC**	*Jul. 11-13*
Experts Meeting on ESMD's non-exploration research portfolio **Washington, DC**	*Jul. 28*
Lunar Science Strategy **Irvine, CA**	*Aug. 2-4*
NASA Astrophysics Performance Assessment —**St Paul, MN**	*Aug. 14-16*
SSB Executive Committee **Woods Hole, MA**	*Aug. 22-24*
Earth Science and Applications From Space, Steering Committee **Woods Hole, MA**	*Aug. 22-24*
Committee on the Astrobiology Strategy for the Exploration of Mars—**Boulder, CO**	*Sept. 13-15*
Committee on the Origins and Exploration of Life—**Boulder, CO**	*Sept. 13-15*
Meeting the Workforce Needs for the National Vision for Space Exploration—**Irvine, CA**	*Sept. 27-29*

FROM THE CHAIR

We are just beginning the human exploration program to return to the Moon—the Vision for Space Exploration that President Bush announced in January 2004. Few if any firm technical decisions have been made. It is, however, the time when critical decisions need to be made as to what are the goals and the strategy for this important endeavor. It will not be possible to evaluate and to agree upon the various competing technical approaches without first knowing what we plan to accomplish and why we are doing it.

There are some who would argue we are going to the Moon because it is national policy, as directed by the President, and now authorized by Congress in the 2005 Authorization Act for NASA. However, this President has only two and a half years remaining in his term. Those of us who believe it is the right path for human exploration, to go forth into the solar system, would like this initiative to continue through multiple Presidential and Congressional terms for generations to come. The foundation for the program needs to be sound, understood, and more widely appreciated and endorsed for such long-term stability.

There are some who believe that the motivations for human return to the Moon are obvious. We explore; it's who we are. In effect, we explore because we are explorers. We need to remember, however, that we have been to the Moon before, with Apollo. We had a clear goal to go and to return safely. But it was not a goal that could sustain the program, and Apollo ended. Having accomplished the task of reaching and returning from the Moon, we were unable to defend our continuing presence there, or the further human exploration of the solar system, against other competing national interests of that time.

From the perspective of science, the process for developing a strategy for what we want to do on the Moon is easy. One of the great successes of the Earth and space science program has been the synergistic relationship that has developed over decades between the Space Studies Board (SSB) and NASA to develop strategies and the community consensus required to execute these strategies. The decadal planning process, initiated by the astrophysicists and now practiced by all Earth and space science disciplines, has ensured the quality of NASA science and generated community ownership and support for the program, which has been necessary for its funding and its success. The SSB, at the request of NASA, has chartered a National Research Council (NRC) study on lunar science to be conducted during the initial phases of robotic and human exploration of the Moon. The SSB is also assisting with planning for life and physical science to be done on the Moon in order to continue human exploration on and beyond the Moon. The NRC studies of lunar science are major efforts and should yield the desired result—of a sound strategy for science we would like to achieve, and can achieve, at least in the near term.

It is very important that the NRC process be allowed to proceed in an orderly way. We do not want to repeat the early history of the Shuttle and the Space Station programs. In those cases, NASA set forth to justify the infrastructure it intended to build by promoting the opportunities it opened up for science, and arranged a series of internal studies and workshops to rationalize the inevitable. This time, we have a unique opportunity in the history of the space program to first define the science we want to do and then to encourage and help formulate the infrastructure that will be required. Proceeding in this way, we can balance the science to be done on and from the Moon against NASA's many other science goals. Only with such balance can we expect a consensus to develop in the science community that will support this effort for the long term.

It is singularly important that balance among the science activities of NASA be maintained. NASA has been willing to spend only a certain limited fraction of its budget on science. The number has varied over the years, and some could argue it is currently at a historical high, but

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FROM THE CHAIR

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nonetheless it is limited. Funds for science on and from the Moon will thus come from other science, unless the NASA overall budget rises, which at present seems unlikely. The largest threat to the stability and support for science in NASA would be the development of disciplinary warfare over limited funds. If science on and from the Moon is to receive broad community support, it will be because this science is conducted in a balanced science program.

The question arises, however, as to who is establishing the goals and strategy by which the human exploration program to the Moon can satisfy broader national interests than science. This could be an appropriate role for the NASA Advisory Council, which, through deliberations or commissioned studies, could determine the criteria for success that meet broad national goals. Strong arguments are needed to defend the program against inevitable questions about whether it will serve the economic wellbeing of the nation, improve our national security, and ensure the preeminence of the United States in space beyond low Earth orbit. Can this program serve to unite disparate nations of the world in an effort on behalf of humankind? Will the program lead to substantial improvements in our space infrastructure for many other applications? Will the program inspire our youth to study science and math and help assure a technologically literate workforce? In the longer term, will the inhabitants of the resource-limited Earth require the broader resources of the solar system?

In my judgment, we are not expending enough effort now to establish the necessary firm foundation for pursuing the goals and strategy for returning humans to the Moon. The underpinnings are not adequate to sustain public and political support for this program. We will need to do better if the sustainability and the success we desire are to be realized. We also cannot say when success is achieved without knowing what success is to be.

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DIRECTOR'S CORNER

This quarter's column was written by Space Studies Board Senior Program Officer David H. Smith. It is based on a talk he recently presented as a guest of the Centro di Astrobiologia in Spain.

NASA's Budget Crises: Past, Present, and Future

Has the current crisis in NASA's science programs left you with a feeling of déjà vu? If so, you are not alone. The agency has experienced major budgetary problems about once per decade for the last 40 years. But, NASA's response to the current crisis is causing much consternation, concern and debate in the scientific community. The combined effects of delays, deferrals, and deletions in NASA science activities triggered by the Bush Administration's FY 2007 budget proposal prompted an SSB committee to conclude that the "program proposed for space and Earth sciences is not robust; it is not properly balanced … and it is neither sustainable nor capable of making adequate progress toward the goals that were recommended in the National Research Council's (NRC) decadal surveys." (*An Assessment of Balance in NASA's Science Programs*, May 2006, see summary on page 7)

NASA weathered budget crises in the early 1970s, early 1980s, and early 1990s. All resulted in significant disruptions to major NASA science projects. Indeed, many, if not all, of the most significant science projects initiated by NASA have followed a tortuous development path from conception to launch. To see what is different now requires an examination of the past.

Representative examples of missions impacted by funding issues in the early 1970s and early 1980s include the following:

- Voyager—Cancelled in 1971 and then revived soon after in a descoped form—Renamed Viking 1 and 2—Launched in 1975.
- Grand Tour—Cancelled in 1972 and then revived soon after in descoped form for 33 percent of the original cost—Renamed Voyager 1 and 2—Launched in 1977 and still operating.
- High-Energy Astronomical Observatories—Cancelled in 1974 and revived in descoped form at 50 percent of original cost—Launched in 1977, 1978, and 1979.
- Large Space Telescope—Cancelled in 1974 and then revived in descoped form in 1978 at 50 percent of original cost—Renamed Hubble Space Telescope—Launched in 1990 and still operating.
- International Solar Polar Mission—NASA spacecraft cancelled in 1981, but development of the European Space Agency (ESA) spacecraft continued—Renamed Ulysses—Launched in 1990 and still operating.
- Venus Orbiting Imaging Radar—Cancelled in 1982 and then revived in descoped form in 1983 at 50 percent of original cost—Renamed Magellan—Launched in 1989.

The take-home message here is that NASA did not attempt to solve budget problems by cutting research and analysis programs and other small programs. Indeed, it can be argued that this period was—in terms of launch rate, if nothing else—the high-water mark of the sounding rocket and Explorer programs. The agency's default policy during these two decades appeared to be to solve budget problems by canceling or descoping a major mission. Although all of the missions listed above were descoped in one way or another, all were, and some still are, exceptionally scientifically productive.

It is the budgetary circumstances of the early 1990s, through, which most closely parallel the current crisis. This was a particularly difficult period for NASA. A series of mishaps with high-profile science missions, including the loss of Mars Observer and the failure of the Galileo spacecraft to deploy its high-gain antenna, generated a great deal of bad publicity for an agency still recovering from the loss of the Space Shuttle Challenger and the embarrassment caused by the Hubble Space Telescope's spherical aberration.

NASA's five-year budget projections for fiscal years 1990 to 1996 exhibited a trend very similar to that of the last few years.

In the early 1990s, federal budget planning assumed that NASA's budget would increase annually. However, by the mid 1990s, the out-year budgetary trends were flat or declining. Projects initiated in the heady days of the late-1980s to the early-1990s that now had to weather significant financial stress included the following:

- Comet Rendezvous/Asteroid Flyby—Descoped in 1990 and then cancelled in 1992.
- Cassini—Almost cancelled in 1992 and then descoped in 1994—Launched in 1997.
- Advanced X-ray Astrophysics Facility—Descoped in 1992 and partly cancelled in 1993—Renamed Chandra X-ray Observatory—Launched in 1999.
- Shuttle Infrared Telescope Facility—Reconfigured in 1990 and descoped in 1993 and 1995—Renamed Spitzer Space Telescope—Launched in 2003.

Again, NASA solved its budgetary issues by descoping its major missions. Research and analysis funding remained healthy and the agency even managed to initiate the Discovery line of small, principal investigator-led solar system exploration missions.

Although its flagship missions were in some disarray, this did not mean that all the news from NASA was bad. By 1996, space science and space science-related discoveries were in the news on an almost weekly basis. Some science stories directly or indirectly related to NASA activities that made headlines in the first half of 1996 included the following:

- The identification of the first extrasolar planets;
- Observations from the Galileo spacecraft suggesting that liquid water exists below Europa's surface;
- Increasing interest in Antarctica's Lake Vostok as a terrestrial analog of an extraterrestrial environment;
- Hubble Space Telescope observations of proto-planetary disks;
- An increasing realization that life exists in extreme terrestrial environments; and
- Claims of evidence of fossils in the martian meteorite ALH84001.

This fortuitous combination of scientific discoveries, against a backdrop of programmatic turmoil, brought space science issues to the forefront of public attention. In preparation for a congressionally-inspired and White House-supported "space summit" in October 1996, the White House's Office of Science and Technology Policy (OSTP) and NASA called upon the SSB to hold a workshop to discuss the implications of the ALH84001 announcement and other recent scientific advances. The resulting workshop concluded that the study of "origins"—be it of life, planetary systems, stars, galaxies, or the universe—would be a powerful organizing theme for NASA's space science activities.

Although the claims about ALH84001 were quickly questioned, the events of 1996 had a profound long-term impact. The dividend came on February 6, 1997, with the announcement of NASA's proposed budget for FY 1998. It included new funds—not a reallocation of existing NASA resources—for the so-called Origins Initiative, which included significantly increased funding for missions to Mars and Europa, a variety of astrophysical activities including the search for extrasolar planets, and the initiation of a major new program in astrobiology. Ironically, these are the very same science programs slated for severe cutbacks in NASA's FY 2007 budget proposal!

What, if anything, can be learned from NASA's quasi-decadal budgetary crises? First, bad times are followed by good. The space science community needs to plan for the future. The events of a decade ago are particularly telling. A budgetary opportunity may be triggered by a spurious event and the scientific community must be ready to exploit it promptly. Second, good times are followed by bad. NASA currently plans to begin the development of the Ares 5 heavy-lift launch vehicle, the new lunar landing module, and the CEV's Earth-escape stage following the retirement of the space shuttle in 2010. The near-simultaneous initiation of three major projects will likely oversubscribe the shuttle dividend and lead to a new round of budgetary belt-tightening in the early years of the next decade.

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BOARD AND COMMITTEE NEWS

THE BOARD AND ITS STANDING COMMITTEES

- The **Space Studies Board** held its 149th meeting on May 2, 2006, at the National Academy of Sciences' building in Washington, D.C. Dr. Michael Griffin, NASA Administrator, discussed NASA's priorities and other issues with Board members.
- The Space Studies Board held its 150th meeting on June 13-15, 2006 at NASA's Johnson Space Center (JSC) in Houston, TX. Mike Coats, Director of JSC, opened the meeting by welcoming the Board and providing an overview of the center. Highlights of the first day included briefings by Wayne Hale, Space Shuttle Program Manager (JSC); Mike Sufferdini, ISS Program Manager (JSC); Paul Marshall (JSC) on the Crew Exploration Vehicle; and John Mather (GSFC), Phil Sabelhaus (GSFC), and Eric Smith (NASA HQ) on the James Webb Space Telescope. Dr. Mary Cleave, Associate Administrator for the Science Mission Directorate (SMD), joined the Board by telecon and provided an overview of SMD activities.

On the second day, Carl Walz (NASA HQ) briefed the Board via telecon on NASA's plans for spending the 15% of ISS research funds set aside by Congress for non-exploration research. Don Thomas (JSC) followed with an update on other ongoing and planned ISS research. Later in the day, Board members enjoyed tours of JSC's planetary science curatorial facilities.

Briefings by Steve Mackwell, Director of the Lunar and Planetary Institute; Benjamin Neumann (NASA HQ), via telecon, on NASA's lunar robotic exploration program; and Jeff Hanley (JSC) on Project Constellation, capped the meeting on the third day.

Farewells were said to several retiring members, including George A. Paulikas (vice chair, Space Studies Board); Reta F. Beebe (chair, Committee on Planetary and Lunar Exploration); Roger D. Blandford (chair, Committee on Astronomy and Astrophysics); Radford Byerly, Jr.; Donald E. Ingber (chair, Committee on Space Biology and Medicine); Ralph H. Jacobson, Calvin W. Lowe; Dennis W. Readey; (chair, Committee on Microgravity Research); and J. Craig Wheeler; who rotated off of the Board on June 30, 2006.

The Board will meet next at the Arnold and Mabel Beckman Center in Irvine, CA, November 14-16, 2006.

- The **Committee on Astronomy and Astrophysics** met May 19-20, 2006, in Washington, D.C. The committee traditionally uses the spring meeting to converse with agency officials and policymakers. This year the committee considered the state of the NASA astrophysics program, in light of the numerous changes at that agency, and also conducted an in-depth discussion of the James Webb Space Telescope (JWST) mission with project leadership. In addition, CAA continued its discussion about various options for conducting the next astronomy and astrophysics decadal survey. The committee will meet next at the Arnold and Mabel Beckman Center, November 28-29, 2006, in Irvine, CA.
- The **Committee on Earth Studies** continues to stand down as work continues on the decadal study.
- The **Committee on Microgravity Research (CMGR)** was mostly inactive 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 chair represented the past work and recommendations of CMGR in the recent SSB study on science balance at NASA. As a reflection of organization changes at NASA, the SSB plans to discontinue this standing committee at the end of this quarter. Future studies relevant to this committee's past work are expected, however, and will be carried out by ad hoc committees as needed.
- The **Committee on the Origins and Exploration of Life** met at the Keck Center of the National Academies in Washington, D.C., on May 10, 2006. At the meeting the committee welcomed its new co-chair, Kenneth Nealson (University of Southern California) and thanked six members for their service to the committee over the last three years. In addition, the committee was briefed on the status of NASA's astrobiology programs, and, in particular, the current and future activities of the NASA Astrobiology Institute. The committee will meet next at the University of Colorado's Laboratory for Atmospheric and Space Physics on September 13, 2006, in Boulder, CO.
- The **Committee on Planetary and Lunar Exploration** held its first meeting of the year, June 5-7, 2006, at the National Academy of Sciences' building in Washington, D.C. The meeting was devoted to NASA solar system programs and the activities of the Lunar Exploration Analysis Group, the Outer Planets Analysis Group, and the Venus Exploration Analysis Group. In addition, the committee discussed future activities relating to the planning of a congressionally-mandated review of NASA's Solar System Exploration Program and the next solar system exploration decadal survey. The committee's next meeting will be held in the fourth quarter of 2006, following the appointment of a new chair and committee members to replace those whose terms ended on June 30, 2006.
- The **Committee on Space Biology and Medicine (CSBM)** was mostly inactive 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 chair represented the past work and recommendations of CSBM in the recent SSB study on science balance at NASA. As a reflection of organizational changes at NASA, the SSB plans to discontinue this standing committee during the next quarter. Future studies relevant to this committee's past work are expected, however, will be carried out by ad hoc committees as needed.
- The **Committee on Solar and Space Physics** published the final version of the report, *Distributed Arrays of Small Instruments (DASI) for Solar-Terrestrial Research: Report of a Workshop*, in May 2006. Some members of the committee also participated in the ad hoc committee that wrote a report summarizing the proceedings of an October 16-20, 2005 workshop that examined the solar- and space physics-related issues—especially those related to the radiation environment beyond Earth—that are associated with fulfillment of NASA's "Vision for Space Exploration." The committee is now developing detailed plans for its next study, which is anticipated to be a study of the impacts (especially economic) and potential for mitigation of severe space weather events.

AD HOC STUDY COMMITTEES

- The **ad hoc Committee on an Assessment of Balance in NASA's Science Programs** met March 6-8, 2006, and delivered its report to NASA and to Congress on May 4, 2006. This report provides the third and final component of the National Research Council's advisory response to a request, as a part of fiscal year 2005 appropriations legislation for NASA that called for "a thorough review of the science that NASA is proposing to undertake under the space exploration initiative and to develop a strategy by which all of NASA's science disciplines … can make adequate progress towards their established goals, as well as providing balanced scientific research in addition to support of the new initiative." The report presents an assessment of NASA's integrated strategy and proposed science program, as set forth in materials that accompany the NASA FY 2007 budget request.
- The **ad hoc Committee on the Astrobiology Strategy for the Exploration of Mars** met at the Keck Center of the National Academies' in Washington, D.C., May 10-12, 2006. In addition to a briefing on the current status on NASA's Mars exploration plans, the committee heard presentations relating to its statement of task. These included: the geological history of Mars, recent results from Mars Express, isotopic biomarkers, the characteristics of sites of possible biological interest on Mars, and the status of astrobiology instrument development. The committee also drafted an outline of its final report and discussed presentations required at its next meeting. The committee will meet next at the University of Colorado's Laboratory for Atmospheric and Space Physics on September 13-15, 2006, in Boulder, CO.
- The **ad hoc 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. The committee held its final meeting May 10-12, 2006, in Irvine, CA. The committee expects to produce its final report in late 2006.
- Work is continuing on identifying a chair and additional members for the a**d hoc Committee on Large Optical Systems in Space**. The committee is being formed in response to a joint request from NASA and the National Reconnaissance Office (NRO). It will conduct a survey and analysis of technology opportunities and issues relevant to the development and operation of medium-size and large optical systems in space. An unclassified study will be prepared, with a separate, classified report or briefing thereafter for NRO.
- The **ad hoc Committee on the Limits of Organic Life in Planetary Systems** did not meet this quarter. The committee has completed an initial draft of its final report. The report will be sent to the NRC external review during the next quarter. Release of the committee's report is tentatively scheduled for Fall 2006.
- The **ad hoc Committee on Meeting the Workforce Needs for the National Vision for Space Exploration,** organized jointly with the Aeronautics and Space Engineering Board, delivered its interim report, *Issues Affecting the Future of the U.S. Space Science and Engineering Workforce*, on April 26, 2006, and released it to the public on April 27, 2006. The committee held its third meeting May 8-9, 2006 at the National Academies' Keck Center in Washington, D.C., to gather additional information and to begin work on its final report. At the meeting the committee heard from representatives from university engineering departments and science departments, held discussions with NASA officials regarding the agency's education strategy and interactions with U.S. universities and regarding the final report of NASA's Systems Engineering and Institutional Transition Team, and received a briefing on university engineering enrollment data from a representative of the American Society for Engineering Education. On May 9, 2006, the committee co-chairs, David Black and Daniel Hastings, met with Scott Pace, the NASA Associate Administrator for Program Assessment and Evaluation, and other NASA officials to discuss future plans for the study. Committee co-chair David Black testified on the conclusions of the Interim Report at a hearing of the House Science Committee's Subcommittee on Space and Aeronautics on June 13, 2006. The committee will meet next at the Arnold and Mabel Beckman Center in Irvine, CA, September 27-28, 2006.
- The **ad hoc Committee on NASA Astrophysics Performance Assessment** is tasked with assessing NASA's performance in achieving the goals laid out by the 2000 NRC astronomy and astrophysics decadal survey, *Astronomy and Astrophysics in the New Millennium*, as well as in the 2003 NRC report *Connecting Quarks with the Cosmos*. The committee held its first meeting June 19-21, 2006, in Washington, D.C. During the meeting, the committee heard from a panel of Congressional staff about the reasons the study was requested, as well as from Eric Smith who presented NASA's perspective on the study. The committee then discussed the current state of the NASA astrophysics program with the chairs of various advisory committees (including the NRC Committee on Astronomy and Astrophysics, the Astronomy and Astrophysics Advisory Committee, and the NASA Astrophysics Subcommittee). Rick Howard and Eric Smith of NASA also presented their assessments of how the current NASA Astrophysics Program measures up to the program laid out in previous NRC reports. The committee will meet next August 14-16, 2006, at the Science Museum of Minnesota in St. Paul, MN.
- The **ad hoc Committee on Planetary Protection Requirements for Venus Missions** did not meet this quarter and has completed its activities. At the suggestion of NASA's Planetary Protection Officer, the poster paper "Reassessment of Planetary Protection Requirements for Venus Missions," by J.W. Szostak, R.L. Riemer, D.H. Smith, and J.D. Rummel was prepared for display at the General Assembly of COSPAR in Beijing, China, in July 2006.
- The slate of members for the **ad hoc Committee to Review the NASA Science Mission Directorate Science Plan** was approved on June 7, 2006. The committee received NASA's draft Science Plan in advance of its July 11-13, 2006 meeting in Washington, D.C. At this meeting, the committee will hear from NASA representatives and congressional staff members. The committee will issue a letter report to NASA during the third quarter. NASA is due to present its final plan to Congress in December 2006.
- The **ad hoc Committee for the Review of the Next Decade Mars Architecture** delivered its letter report to the sponsor on June 30, 2006. The letter report, without references, is reprinted later in this newsletter.

- The **ad hoc Committee on the Scientific Context for the Exploration of the Moon** held its first meeting at the Keck Center of the National Academies in Washington, D.C., June 20-22, 2006. The committee was briefed on a variety of current issues in lunar science. In addition to discussing presentations required at future meetings and drafting an outline for its interim report – scheduled for release during the third quarter of 2006 – the committee also discussed outreach activities designed to engage the international lunar science community in its activities. Outreach activities will begin at the meeting of the International Lunar Exploration Working Group in Beijing, China in July 2006. Additional outreach activities will take place at a variety of meetings including the American Astronomical Society Division for Planetary Sciences meeting in Pasadena, CA, in October 2006 and the American Geophysical Union meeting in San Francisco, CA, in December 2006.
- The **ad hoc Committee on the Solar System Radiation Environment and NASA's Vision for Space Exploration: A Workshop** produced a report *The Solar System Radiation Environment and NASA's Vision for Space Exploration: A Workshop*, which was awaiting approval by the NRC as the quarter ended. The final report will be released in August 2006. NASA has asked the Aeronautics and Space Engineering Board (ASEB) to consider a long-term study of this issue.
- The **Task Group on Organic Environments in the Solar System** did not meet this quarter. Work on revising the report in response to reviewer's comments has been completed and the task group is awaiting final approval of the report by the NRC. Release of the committee's report is tentatively scheduled for Fall 2006.
- The SSB decadal survey, "**Earth Science and Applications from Space (ESAS): A Community Assessment and Strategy for the Future** (http://qp.nas.edu/decadalsurvey)," will generate consensus recommendations from the Earth science community regarding a systems approach to the space-based and ancillary observations that encompass the research programs of NASA and the related operational programs of NOAA and the USGS. An interim report was published in April 2005, and a final report, which will include prioritized recommendations directed at NASA, NOAA, and the USGS, is anticipated by the end of calendar year 2006.

The ESAS study is led by an 18-member steering (executive) committee and seven thematically organized study panels:

1. Earth Science Applications and Societal Benefits
2. Land-use Change, Ecosystem Dynamics and Biodiversity
3. Weather (including space weather and chemical weather)
4. Climate Variability and Change
5. Water Resources and the Global Hydrologic Cycle
6. Human Health and Security
7. Solid-Earth Hazards, Resources, and Dynamics

During the quarter, the following meetings took place:

- ESAS Steering Committee: May 2-4, 2006 (Irvine, CA)
- Panel on Land-use Change, Ecosystem Dynamics and Biodiversity: April 24-25, 2006 (Washington, D.C.)

Each of the seven panels has now held its 3rd and final meeting. The steering committee will hold its last scheduled meeting August 22-24, 2006, at the J. Erik Jonsson Center in Woods Hole, MA.

Congratulations to Dr. Ruth DeFries, chair of the ESAS Panel on Land-Use Change, Ecosystem Dynamics and Biodiversity, on being elected as a member of the National Academy of Sciences,

Members of the ESAS Steering (Executive) Committee and Representatives from the ESAS Panels at a May 2-4, 2006 Meeting in Irvine, CA at the Arnold & Mabel Beckman Center.

on April 25, 2006. She received the news via telephone while chairing the April 25, 2006, Ecosystems Panel Meeting in Washington, D.C. She was pleasantly surprised!

- Two activities that are relevant to the past work of **CSBM** and **CMGR** are being organized to look at laboratory sciences in space. The first is an **experts' meeting**, scheduled for July 28, 2006, in Washington, D.C., that will be organized and convened on behalf of NASA to examine NASA's current non-exploration portfolio balance and selection criteria in the areas of basic biological and physical research. The meeting participants will discuss their own views directly with NASA during the meeting and no report will be produced.

In the second activity, an ad hoc committee will organize **a workshop to gather community input on the key scientific and technological questions that can be addressed on or from the Moon**. The study will focus on laboratory sciences—as opposed to observational sciences, which are the topic of another study that is currently underway. The committee will review input from the workshop, past reports, and relevant NASA workshops. This activity is intended to be a precursor to further studies to assess the key issues identified.

- The **International Council for Science's** (ICSU's) **Committee on Space Research** (COSPAR) continued with planning activities for the organization's 36th Scientific Assembly, which will be held in Beijing China July 2006. <http://www.cosparhq.org/Meetings/meetings>. Abstracts for the meeting were due February 17, 2006. COSPAR will be moving from its current location in Paris to an as-yet-undetermined location by the end of 2006 because the French government, which owns the building housing COSPAR and other units of the ICSU, has sold it.

NEW RELEASES FROM THE SSB

Summaries are reproduced without reference or notes. Copies of reports are available from the SSB office at 202-334-3477 or online at http://www.nap.edu/.

An Assessment of Balance in NASA's Science Programs

This report by the Committee on An Assessment of Balance in NASA's Science Programs is available online at http://newton.nap.edu/catalog/11644.html. The study was staffed by Joseph K. Alexander, Study Director, Dwayne A. Day, Research Associate, Catherine A. Gruber, Assistant Editor, and Claudette Baylor-Fleming, Administrative Assistant. The following is adapted from the executive summary of the report.

An Assessment of Balance in NASA's Science Programs provides the third and final component of the National Academies' advisory response to a request, as a part of fiscal year 2005 appropriations legislation for NASA, that called for "a thorough review of the science that NASA is proposing to undertake under the space exploration initiative and to develop a strategy by which all of NASA's science disciplines … can make adequate progress towards their established goals, as well as providing balanced scientific research in addition to support of the new initiative." The report presents an assessment of NASA's integrated strategy and proposed science program, as set forth in materials that accompany the NASA FY 2007 budget request.

The report concludes that while NASA science has served the nation broadly in ways that expand our intellect, enhance our culture, improve our economic security, and generally enrich the nation and the world, the overall viability of the future of the science program is now seriously threatened. In particular, the report presents five major conclusions and accompanying recommendations.

1. NASA is being asked to accomplish too much with too little. The agency does not have the necessary resources to carry out the tasks of completing the International Space Station, returning humans to the Moon, maintaining vigorous Earth and space science and microgravity life and physical sciences programs, and sustaining capabilities in aeronautical research. Therefore, both the Executive and Legislative branches of the government need to seriously examine the mismatch between NASA's assigned tasks and resources and identify actions that will make the agency's portfolio of responsibilities sustainable.
2. The program proposed for Earth and space sciences is not robust; it is not properly balanced to support a healthy mix of small, medium, and large missions and an underlying foundation of scientific research and advanced technology projects; and it is neither sustainable nor capable of making adequate progress towards its established goals. Therefore, NASA should move immediately to correct the problems caused by reductions in the base of research grants, small missions, and technology for future missions before the essential pipeline of human capital and technology is irrevocably disrupted.
3. The NASA microgravity life and physical science programs have suffered severe cutbacks that will lead to major reductions in the ability of scientists in these areas to contribute to NASA's goals of long duration human spaceflight. Therefore, within the funding constraints that NASA faces, every effort should be made to preserve the essential ground-based and flight research to enable long-duration human spaceflight and to continue to foster a viable community that will ultimately be required to achieve the human spaceflight goals of the exploration vision.
4. The major missions in Earth and space science are being executed at costs well in excess of the estimated costs at the time when they were recommended in the NRC's decadal surveys for their disciplines. Consequently, the orderly planning process that has served the Earth and space science communities well has been disrupted, and balance among large, medium, and small missions has been difficult to maintain. Therefore, NASA should undertake a systematic and comprehensive evaluation of the cost-to-complete of each of its Earth and space science missions that are under development, for the purpose of determining the adequacy of budget and schedule.
5. A past strength of the NASA science programs, both in their planning and execution, has been the intimate involvement of the scientific community. Some of the current mismatch between the NASA plans for the next five years and a balanced and robust program stems from the lack of an effective internal advisory structure. Therefore, NASA

should engage its reconstituted advisory committees as soon as possible to carry out the actions called for in recommendations 3 and 4 above.

Issues Affecting the Future of the U.S. Space and Engineering Workforce: Interim Report

This report by the Committee on Meeting the Workforce Needs for the National Vision for Space Exploration is available online at http://newton.nap.edu/catalog/11642.html. The study was staffed by Joseph K. Alexander, Study Director, Dwayne A. Day, Research Associate, Catherine A. Gruber, Assistant Editor, and Celeste A. Naylor, Senior Program Assistant. The following is adapted from the executive summary of the report.

Issues Affecting the Future of the U.S. Space Science and Engineering Workforce: Interim Report provides an initial response to NASA's request that the Space Studies Board and the Aeronautics and Space Engineering Board assess the current and future supply of qualified U.S. aerospace professionals and identify realistic and actionable solutions to meeting any identified needs. The report presents a summary of highlights of a January 2006 workshop and February 2006 study committee meeting, and it provides some preliminary findings with respect to (1) current and projected characteristics of the workforce, (2) factors that impact the demographics of the affected workforces, and (3) NASA's list of the workforce skills that will be needed to implement the nation's vision for space exploration, both within the government and in industry.

The report notes that NASA has made a reasonable start on assessing its near- and long-term skill needs, and the study committee shares the view expressed by NASA representatives that there is still much more work to be done. Therefore the report recommends that NASA should develop a workforce strategy that deals with the next five years and that lays the foundation for a longer-term process to target, attract, train, and retain the skilled personnel necessary to implement the vision for space exploration and conduct its other missions in the next 5 to 15 years.

The committee has not seen compelling evidence for a looming, broadly-based shortage in the supply of aerospace science and engineering workforce employees to meet NASA's needs. The agency, like other government agencies and aerospace contractors, is encountering difficulty in finding experienced personnel in certain specific areas, such as systems engineers and project managers. To address those skill areas where there are concerns (both for the near term and the longer term), the report recommends that NASA should adopt innovative methods of attracting and retaining its required personnel, obtain the necessary flexibility in hiring and reduction-in-force procedures to enable it to acquire the people it needs, work closely with the DOD to initiate similar training programs to those that DOD has initiated or participate actively in the DOD programs, and expand and enhance agency-wide training and mentorship programs that afford "hands-on" experience development opportunities.

Finally, the report concludes that the ability to recruit and strategically retain the needed workforce will depend fundamentally on the long-term stability of the vision for space exploration and a sustainable national consensus on NASA's mission.

Review of the Next Decade Mars Architecture: Letter Report

On June 30, 2006, Reta F. Beebe, chair of the ad hoc Committee for the study "Review of the Next Decadal Mars Architecture" sent a letter report to Dr. Mary Cleave, NASA's Associate Administrator for the Science Mission Directorate. The letter report is available online in PDF format at http://newton.nap.edu/catalog/11690.html. The study was staffed by David H. Smith, study director, Brendan McFarland, research assistant, and Rodney Howard, senior program assistant. The following is adapted from the transmittal letter to Dr. Cleave.

In your letter of December 29, 2005, to Space Studies Board (SSB) Chair Lennard Fisk, you explained that new scientific results from ongoing Mars missions, together with changes in funding levels for the Mars Exploration Program, have compelled the Science Mission Directorate to revisit the program's architecture and the sequence of missions planned for launch to Mars after 2010. As a result you requested that the SSB review and evaluate the new architecture in a time frame to support NASA approval of the Mars Exploration Program's revised architecture in mid-summer of 2006. In particular, you requested that the SSB address the following questions:

- Is the Mars architecture reflective of the strategies, priorities, and guidelines put forward by the National Research Council's (NRC's) solar system exploration decadal survey and related science strategies and NASA plans?
- Does the revised Mars architecture address the goals of NASA's Mars Exploration Program and optimize the science return, given the current fiscal posture of the program?
- Does the Mars architecture represent a reasonably balanced mission portfolio?

In response to your request, the ad hoc Mars Architecture Assessment Committee was established.

In response to the question, "Is the Mars architecture reflective of the strategies, priorities, and guidelines put forward by the NRC's solar system exploration decadal survey and related science strategies and NASA plans?", **the committee finds that the proposed Mars architecture addresses some of the strategies, priorities, and guidelines promoted by the solar system exploration (SSE) decadal survey and the Mars Exploration Program Analysis Group (MEPAG) and is basically consistent with NASA's plans as exemplified by the agency's 2006 strategic plan and the Vision for Space Exploration. However, the absence of a sample return mission and a geophysical/meteorological network mission runs counter to the recommendations of the SSE decadal survey and significantly reduces the architecture's scientific impact. Other topics of concern include the lack of well-defined mission parameters and scientific objectives for the Mars Science and Telecommunications Orbiter, Astrobiology Field Laboratory, and Mid Rover missions; issues relating to the phasing and responsiveness of these missions to the results obtained from past missions; and the incompletely articulated links between these missions and the priorities enunciated by the SSE decadal survey and MEPAG.**

The committee offers the following recommendations to NASA:

- ***Recommendation:*** **Include the Mars Long-Lived Lander Network in the mix of options for the 2016 launch opportunity.**
- ***Recommendation:*** **Consider delaying the launch of the Astrobiology Field Laboratory until 2018 to permit an informed decision of its merits and the selection of an appropriate instrument complement in the context of a mature consideration of the results from the Mars Science Laboratory and other prior missions.**
- ***Recommendation:*** **Establish science and technology definition teams for the Astrobiology Field Laboratory, the Mars Science and Telecommunications Orbiter, the Mid Rovers, and the Mars Long-Lived Lander Network as soon as possible to optimize science and mission design in concert with each other. (This model has been employed successfully by the heliospheric community.)**
- ***Recommendation:*** **Devise a strategy to implement the Mars Sample Return mission, and ensure that a program is started at the earliest possible opportunity to develop the technology necessary to enable this mission.**

In response to the question, "Does the revised Mars architecture address the goals of NASA's Mars Exploration Program and optimize the science return, given the current fiscal posture of the program?", **the committee finds that it cannot definitively say whether or not the revised Mars architecture addresses the goals of NASA's Mars Exploration Program because the architecture lacks sufficient detail with respect to the science and the cost to allow a complete evaluation. The various mission options are, as stated above, incompletely defined, and the strategic approach to, and the selection criteria to distinguish among, various mission options are lacking. The presence of Mars Scout missions in the architecture is welcomed because they help to optimize the science return and provide balance. Nevertheless, the Mars architecture as a whole is not optimized, because the importance of foundational strategic elements—for example, research and analysis programs and technology development—is not articulated.**

In response to this finding, the committee offers the following recommendations to NASA:

- ***Recommendation:*** **Develop and articulate criteria for distinguishing between the three options for missions to launch in 2016. Similarly, define a strategy that addresses the short lead time between science results obtained from the Mars Science Laboratory and selection of the mission to fly in 2016.**
- ***Recommendation:*** **Clarify how trade-offs involving mission costs versus science were made for the various launch opportunities to justify the rationale behind the proposed sequence of specific missions and the exclusion of others.**
- ***Recommendation:*** **Maintain the Mars Scouts as entities distinct from the core missions of the Mars Exploration Program. Scout missions should not be restricted by the planning for core missions, and the core missions should not depend on selecting particular types of Scout missions.**
- ***Recommendation:*** **Immediately initiate appropriate technology development activities to support all of the missions considered for the period 2013-2016 and to support the Mars Sample Return mission as soon as possible thereafter.**
- ***Recommendation:*** **Ensure a vigorous research and analysis (R&A) program to maintain the scientific and technical infrastructure and expertise necessary to implement the Mars architecture, and encourage collaboration on international missions.**

In response to the question, "Does the Mars architecture represent a reasonably balanced mission portfolio?", **the committee finds that in the context of the basic types of missions, the Mars architecture is a reasonably well balanced one: both landed and orbital missions are included in an appropriate mix, given the current state of Mars exploration. To the extent that the specific science objectives of the proposed missions are defined, one of the three crosscutting themes for the exploration of Mars identified in the SSE decadal survey is largely neglected, as are very high priority topics related to understanding near-surface and boundary-layer atmospheric sciences, and so, in this respect, balance is sorely lacking.**

To optimize efforts to implement a balanced portfolio of missions, the committee offers the following recommendations to NASA:

- ***Recommendation:*** **Include the Mars Long-Lived Lander Network in the mix of options for the 2016 launch opportunity.**
- ***Recommendation:*** **If the Mars Long-Lived Lander Network cannot be implemented in the period under consideration, provide for an effort to make some of the highest-priority measurements on the landed missions that are included in the proposed Mars architecture.**
- ***Recommendation:*** **Ensure that the primary role of the Mars Science and Telecommunications Orbiter is to address science questions, and not simply to serve as a telecommunications relay. This distinction is particularly important with respect to the required orbital parameters that are adopted.**

CONGRESSIONAL HEARINGS OF INTEREST

SSB staff members attended several congressional hearings during this past quarter relating to NASA's FY 2007 budget request.

Senate Commerce Committee, Science and Space Subcommittee
Testifying: Michael Griffin, NASA Administrator
http://commerce.senate.gov/hearings/witnesslist.cfm?id=1836
Attended by: Tanja Pilzak, SSB Administrative Coordinator

The U.S. Senate Commerce Committee's Science and Space Subcommittee met on April 25, 2006, at 2:30 p.m. to hold a hearing with NASA Administrator Michael Griffin on National Aeronautics and Space Administration (NASA) Issues and Challenges. The hearing reviewed NASA's progress in implementing provisions of the NASA Authorization Act of 2005 (P.L. 109-155) in the context of the Fiscal Year 2007 budget request; ISS Research; the transition from the Space Shuttle to the CEV, including how NASA will deal with the planned 2010-2014 gap and the possibility of utilizing commercial avenues; NASA activities in science and engineering education; and contributions to U.S. technological competitiveness. The hearing also reviewed the global competitiveness of the U.S. in the Aeronautics industry and the workforce issues that may occur when NASA transitions from the Shuttle to the CEV.

Senate Appropriations Committee, Subcommittee on Commerce, Justice, Science and Related Agencies
Testifying: Michael Griffin, NASA Administrator
Attended by: Rodney Howard, SSB Senior Program Assistant

The Commerce, Justice, Science, and Related Agencies Subcommittee of the U.S. Senate Committee on Appropriations met on April 26, 2006, to review the FY 2007 budget request for the National Aeronautics and Space Administration with NASA Administrator Michael Griffin. Specifically, how NASA plans to balance the many internal and external influences on the program, including, but not limited to, the President's Vision for returning to the moon, the reduction in the level of funding for science and aeronautics initiatives, a new crew return vehicle, a fully functional Space Station, and a repaired Hubble telescope.

Senate Commerce Committee, Subcommittee on Science and Space
Testifying: Dr. Peter Voorhees, Dr. Ray Torbert, Dr. Jim Pawelczyk and Major General Charles Bolden Jr. (Ret.)
Attended by: Stephanie Bednarek and Brendan McFarland, SSB Summer Interns

On June 7, 2006, the Senate Subcommittee on Science and Space held a hearing to invite outside perspectives on NASA's budget and programs. The hearing stressed NASA budgetary concerns, with emphasis placed on NASA being asked to accomplish both human spaceflight and science goals without adequate funding. Concerns over the cuts to research within NASA's budget were at the forefront of the discussion with all of the witnesses. The subcommittee was warned by the witnesses that cutting research funds would lead to a dwindling of expertise in specialized fields, which could not be rejuvenated on a short term basis. The NRC's recent report An Assessment of Balance in NASA's Science Programs was referenced multiple times across the panel, specifically the first finding which states that NASA is being asked to accomplish too much with too little. The hearings were concluded with the witnesses and subcommittee in general agreement that increasing NASA's funding for scientific research was necessary to complete the President's Vision for Space Exploration and maintain the vitality of the nation's scientific future.

CONGRESSIONAL TESTIMONY

During the past quarter, two hearings were held where members of the SSB family testified to Congress. Their prepared statements, which may be of interest to readers of this newsletter, are reprinted below. First was the June 7 hearing before the Senate Commerce Committee's Science and Space Subcommittee where incoming Board member James Pawelczyk, and former Board member Peter Voorhees, testified on outside perspectives regarding NASA's FY2007 budget request. The prepared statements of other witnesses are available at http://commerce.senate.gov. Second was a June 13 hearing where David Black, co-chair of the NRC's ad hoc Committee on Issues Affecting the Future of the U.S. Space Science and Engineering Workforce, testified to the House Science Committee's Space and Aeronautics Subcommittee on behalf of the NRC concerning the findings and recommendations of his committee's interim report. The prepared statements of other witnesses are available at http://www.house.gov/science.

NASA Budget and Programs: Outside Perspectives
Senate Commerce Committee
June 7, 2006

Statement by
James A. Pawelczyk, Ph.D.
Associate Professor of Physiology, Kinesiology and Medicine
The Pennsylvania State University

Abstract

At the midpoint between the Apollo program and a human trip to Mars, NASA's recent reductions to scientific funding are unprecedented. In particular, the thoughtfully conceived architecture to explore the Moon, Mars and beyond has produced large reallocations of research funding that jeopardizes the stability and future of space life sciences. Given current budgets, NASA does not appear to have sufficient resources to fully engage the help of the external science community to complete the President's Vision for Space Exploration.

Madame Chairperson and Members of the Committee:

Good afternoon. I thank you for the opportunity to discuss the changes NASA has made to its research funding. I have been a life sciences researcher for 20 years, competing successfully for the past 13 years for grants from NASA. From 1996-1998 I took leave from my academic position at The Pennsylvania State University to serve as a payload specialist astronaut, or guest researcher, on the STS-90 Neurolab Spacelab mission, which flew on the space shuttle Columbia in 1998. Since Neurolab I have had the privilege to serve as a member of NASA's Research Maximization and Prioritization (ReMAP) Taskforce. More recently I helped evaluate NASA's Bioastronautics Research Program for the Institute of Medicine, NASA's International Space Station Research Plan for the National Research Council, and the progress of the National Space Biomedical Research Institute (NSBRI).

During a January 19, 2006 interview with the Orlando Sentinel, Mr. Griffin shared his thoughts about his first 9 months in the position of NASA Administrator. When asked about the lessons learned from the Challenger and Columbia accidents, he stated the following:

> If you spend much time on this stuff and aviation accidents, a common theme is that of not listening to the signals the hardware is sending – the test results, the flight results, *the dissenting opinions of the people involved*. So a common theme is not listening. And I don't mean actively shutting out. I mean being so focused on what we're trying to do that *we're not aware of what nature is telling us* [emphasis added].

Those insights are remarkably prophetic, and today I find myself before you as one of those dissenters. I share Mr. Griffin's passion for the human exploration of space, but I must conclude with equal conviction that biological adaptation is a serious risk to an extended human presence in space, and that the scientific research necessary to ensure the health and safety of future astronaut crews beyond low-earth orbit is far from complete.

ReMAP – antecedent to the Vision for Space Exploration

For several years, NASA has recognized and responded to its need to complete necessary research in a fiscally responsible manner. In the spring and summer of 2002 NASA launched the Research Maximization and Prioritization Task Force, commonly known as ReMAP. Chaired by Rae Silver of Columbia University, the Task Force included two National Medal of Science awardees, one Nobel Prize winner, and more than a dozen members of the National Academy of Sciences, representing the breadth of translational research in the biological and physical sciences.

ReMAP was asked to prioritize 41 areas of research in the former Office of Biological and Physical Research. What was unique to ReMAP was our challenge to consider both the physical sciences and biological sciences simultaneously. This resulted in spirited debate and intellectual foment of the highest caliber. When we completed our task, highest priority was assigned to 13 areas that informed two broad, often overlapping, goals: One is the category of intrinsic scientific importance or impact; research that illuminates our place in the universe, but cannot be accomplished in a terrestrial environment. The other goal values research that enables long-term human exploration of space beyond low-earth orbit, and develops effective countermeasures to mitigate the potentially damaging effects of long-term exposure to the space environment. It should be no surprise to you that over the past 17 years other review panels, both internal and external to NASA, have named similar goals.

The Task Force wrestled with the question whether one goal could be prioritized over the other. In the history of the United States space program both goals have been important, though their relative importance has changed over time. The limited amount of biological and physical research that occurred during early space exploration, particularly the Apollo era, focused on the health and safety of astronaut crews in a microgravity environment. Significant research questions that did not contribute directly to a successful Moon landing received lower priority. In contrast, more regular access to space provided by the space shuttle afforded an opportunity for "basic" research to take higher priority; the proliferation of space based research in the physical and biological sciences over the past twenty years is a testament to this fact.

Thus, the relative priority of these two goals of research - enabling long-term human exploration of space and answering questions of intrinsic scientific merit - has shifted during NASA's history. This conclusion is critical, as it suggests that one goal can receive higher priority over the other, though this ranking may change depending on NASA's definition of programmatic needs at a particular point in time.

When the President announced the Vision for Space Exploration in January of 2004, the relative balance between these two categories of research changed again. Items in NASA's research portfolio that most contributed to exploration goals would take precedence over experiments with intrinsic scientific importance and impact, and substantial realignment has occurred as a result. At the same time, the Office of Biological and Physical Research, the entity responsible for funding biological and physical research at NASA, was absorbed into the Exploration Systems Mission Directorate.

I share Mr. Griffin's view that aligning research with exploration goals is a good thing. However, naïve or wholesale elimination of scientific themes is not, and biological and physical research has certainly suffered from this effect. To the alarm of the scientific community, the process that began with ReMAP has taken a dangerous turn. Areas that we rated as highest priority, including those that contribute to exploration goals, have been de-scoped or eliminated completely.

Where is "science" at NASA today?

In many ways, the reorganization of "science" at NASA orphaned biology, and I encourage caution when you and your colleagues use the term in your discussions. Logically, "science" would seem an appropriate, generic label for research activities that occur throughout the agency. However, within NASA it appears to have a more specific meaning, often referring exclusively to the activities funded by the Science Mission Directorate, which includes the following disciplines only:

- Astrophysics - the study of matter and energy in outer space.
- Earth Science - the study of the origins and structure of our planet.
- Heliophysics - the study of planets, interplanetary space, and the sun.
- Planetary Science - the study of the origins, structure, and features of planets beyond our own.

Please note that the term, “biology,” or the study of life, does not appear at all. To my more skeptical colleagues, the science of biology is disappearing at NASA.

The available evidence provides some support for this conclusion. While the Science Mission Directorate has suffered modest cuts, over the past two years, funding for biological and physical research (i.e., science not managed by the Science Mission Directorate) has decreased almost 75%, from $1,049M in FY05 to $274M in the FY07 Budget Summit. This includes the cancellation of virtually all research equipment for the International Space Station that supports animals and plants, the elimination of 20% of the funding for external research grants, and the premature termination of 84% of these grants. Approximately 500 life science graduate students in 25 states will be affected.

The next generations of space life scientists perceive a bitter lesson that is difficult to assuage: as the result of a shell game of agency-wide reorganization, life science is no longer recognized or valued within NASA.

Biological research is essential and obligatory to the Vision for Space Exploration

I wholeheartedly endorse the President’s goal to return humans to the Moon and Mars, but the current reductions in biological research funding appear sorely at odds with this goal. Simply put, the biological risks associated with exploration-class spaceflight are far from being mitigated.

This conclusion is based on analysis of 30 years of NASA-sponsored research. Since the days of Skylab NASA-funded investigators conducted an aggressive and successful biological research program that was robust, comprehensive, and internationally recognized. Beginning with those early efforts, and continuing with our international partners on the *Mir* and the International Space Station, we have built a knowledge base that defines the rate at which humans adapt during spaceflight up to six-months duration, with four data points exceeding one-year duration.

Musculoskeletal deconditioning remains a paramount concern. In the past two years our ability to differentiate the trabecular bone network in the hip has helped us to appreciate that the risk to bone during spaceflight may be even greater than we previously anticipated. The rate of osteoporosis in astronauts equal patients with spinal cord injury, and exceeds that seen in post-menopausal women by a factor of 10 or more. Extrapolating from published studies of astronauts and cosmonauts spending up to six months in low-earth orbit, we can offer preliminary estimates of the changes that would occur if humans made a 30-month trip to Mars today:

- 100% of crew members would lose more than 15% of their bone mineral in the femur and hip
- Approximately 80% would lose more than 25% of their bone mineral
- More than 40% would lose greater than 50% of their bone mineral
- Approximately 20% would lose more than 25% of their exercise capacity
- Approximately 40% would lose experience a decline in leg muscle strength of 30% or more

Each of these predictions takes into the account the fact that astronauts would be using the best countermeasures available currently! To my knowledge, no engineer would accept a spaceflight system where such degradation is expected. Nor should it be so for astronauts.

What is the status of NASA’s human biological risk mitigation plan?

In 2005 NASA’s Chief Medical Officer asked the Institute of Medicine to evaluate NASA’s Bioastronautics Roadmap, the comprehensive plan to document and reduce the biological risks to human spaceflight. Despite the alarming data I just described to you, we found that concern for these risks varied widely among astronauts, flight surgeons, and mid-level management. None of the 183 proposed risk mitigation strategies had been implemented for spaceflight, and approximately 2/3 of these strategies were considered to be so incompletely developed that they would not be addressed further.

In his 2001 book, Enlightened Experimentation: The New Imperative for Innovation, Harvard Business professor Stefan Thomke offered the following four rules for enlightened experimentation: organize for rapid experimentation; fail early and often, but avoid mistakes; anticipate and exploit early information; and combine new and old technologies. While these principles are recognizable in NASA’s Constellation System architecture, they are wholly absent in the implementation of NASA’s Bioastronautics Roadmap.

We desperately need to increase human capabilities in space by translating findings from cell culture to reference organisms and mammalian models such as mice and rats to future flight crews. Translational research is the "gold standard" of the NIH, and it is what the research community, and the American people, should expect from the International Space Station. We need the capability to house and test model organisms on the ISS. But equally important, we need adequate time for crew to prepare and conduct these experiments, and that time can be found only when the ISS moves beyond the core complete configuration. The potential return is immense; the application of this research to our aging public could become one of the most important justifications for an extended human presence in space.

Challenges for the future

Earlier this year, Congress received The National Research Council’s review of NASA’s plans for the International Space Station, which identified several serious concerns about NASA’s prioritization process for current and planned life and physical sciences research.

First, allocations to research did not appear to be based on risk, but convenience. Second, little emphasis was given to future lunar or Martian outposts, opting instead for short stays on the Moon. Third, the current ISS payload and the processes used to prioritize research areas appeared to be neither aligned with exploration mission needs nor sufficiently refined to evaluate individual experiments. Finally, no process was in place to plan or integrate future research needs that may not be recognized currently.

To restore scientific credibility at NASA, a coordinated strategy is necessary. I offer several recommendations for your consideration:

- First, add sufficient funding to NASA's budget, both to answer the questions essential to the Vision for Space Exploration and to replace the Space Shuttle in a timely fashion. An addition of $150M would restore biological funding to the level of the President's FY06 budget request, but a minimal biological research program, directed primarily to external investigators, could be conducted with the addition of approximately $50M/year.
- Second, articulate a timeframe for delivering and completing a risk mitigation plan for humans exploring the Moon and Mars, and vet both the plan and the timeframe with the external scientific community.
- Third, develop a comprehensive plan for conducting research on board the International Space Station without the space shuttle, including addition of essential equipment for animal research, deployment of a crew of at least six people, and logistics that are sufficient to keep these crews safe and supplied.
- Finally, establish sufficient oversight to hold NASA accountable to these goals.

Madame Chairperson, members of the committee, make no mistake about this: in the long-term, we are retaining and accumulating human risk to spaceflight in order to progress with an under-funded Vision for Space Exploration. We have an ethical obligation to our current and future space explorers, and to the American public, to do better. Given sufficient resources, I remain optimistic that NASA can deliver the rigorous translational research program that the scientific community expects, and the American people deserve. I sincerely thank you for your vigilant support of the nation's space program, and the opportunity to appear before you today.

Written Testimony of Peter W. Voorhees

Department of Materials Science and Engineering
Northwestern University

Introduction

Chairwoman Hutchison, Ranking Member Nelson, and members of the committee, thank you for inviting me to testify today. My name is Peter Voorhees. I am the Frank C. Engelhart Professor and Chair of the Department of Materials Science and Engineering at Northwestern University. I was a member of the National Research Council Space Studies Board and Chair of the Committee for Microgravity Research. Through my tenure as Chair I have become familiar with the microgravity program and many of the areas within the physical sciences that are at the core of NASA's human exploration effort.

I believe that a strong physical sciences research program is crucial to both capitalizing on NASA's significant past investment in this area and to enabling the human spaceflight program. In 2004 President Bush provided a clear vision for NASA's human spaceflight effort and NASA has fully embraced the goal of returning humans to the Moon and eventually sending humans to Mars. However, to accomplish these goals research in the physical sciences is necessary to gain a more complete understanding of effects of microgravity on a wide range of processes as well as develop a variety of technologies to ensure the safety and success of these missions. Only by supporting an ongoing physical sciences research program will NASA be able to avoid failures that could have been anticipated by an ongoing physical sciences research program and to implement the President's vision in the most cost-effective and rapid fashion.

The Development of the Physical Sciences Research Program

The evolution of NASA's physical sciences research program provides important lessons for how to formulate a successful research program to enable human space exploration. NASA's physical sciences research program began as the materials processing in space effort during the Skylab era. The program was singularly focused on performing experiments in space. As a result, many of the experiments were ill-conceived and few yielded new insights into the physical phenomena that were operative in space or impacted their respective scientific communities. In the early 1990s a new paradigm for research was initiated in the fluids, materials, combustion and fundamental physics research areas. In order to attract the best researchers, a concentrated out-reach effort was undertaken and a rigorous peer review system was instituted. In addition, a large ground-based research program was created that ensured that ideas were refined and scientific questions identified that could be answered only through space flight experiments. As a result the "shoot and look" approach to performing experiments during the Skylab era was replaced by carefully conceived hypothesis driven experiments. At its peak there were approximately 500 investigators in the program and it supported 1700 research students.

The 2003 National Research Council (NRC) study "Assessment of the Directions in Microgravity and Physical Sciences Research" found the quality of the investigators in the program to be excellent. On the basis of an analysis of the citations of the papers published, prominence of journals in which the papers appeared, the influence of the research on the content of textbooks, documented influence on industry and the quality of the investigators in the program, we found that the microgravity program has had a significant impact on the fields of which it was a part. For example, 37 members of the fluids program were fellows of the American Physical Society, the materials science program produced some of the most highly cited papers in the area of solidification and crystal growth, and the fundamental physics program was funding six Nobel laureates. Many billions of dollars were invested in creating this successful and influential program.

NASA should take great pride in the creation of this high quality physical sciences research program in the fluids, combustion, materials and fundamental physics areas. It evolved into one of the jewels in NASA's crown. With the growth in the quality of the program NASA became the primary source of funding for research in areas such as crystal growth, low temperature physics, and low Reynolds number and interfacial fluid flow making NASA stewards of these important and broad scientific areas.

In early 2001 it became apparent that the International Space Station (ISS) program was facing major cost overruns. These financial constraints led to a major reduction in the microgravity research that had been planned for the ISS. Many of the experimental facilities that were planned were either reduced in size or delayed and the number of crew aboard the ISS was cut, making it difficult to perform experiments during the construction phase of the project. As a result, flight experiments were delayed or effectively cancelled. The catastrophic loss of the Columbia orbiter in 2003 placed even more serve restrictions on the ability to transport samples and experimental equipment to and from the ISS.

The challenges posed by these recent events, the need to retire the Shuttle by 2010, as well as develop the Crew Exploration Vehicle have placed great pressures on NASA's budget. These financial constraints have resulted in a major reduction in the size and scope of the physical sciences research program. For example, with breathtaking speed and no external input NASA eliminated the Office of Biological and Physical Research, and the Physical Sciences division within the office. The number of principal investigators has been reduced to less than 100 with still more reductions proposed. NASA's physical sciences research effort is on the verge of elimination. FY07 is the last chance to keep physical sciences research at NASA alive.

Rationales for Physical Sciences Research at NASA

The raison d'être for physical sciences research at NASA lies in both the past and future. Since 1990 NASA has been investing significant resources, measured in the billions of dollars, in developing and maintaining a community of high quality researchers in the microgravity sciences arena. The focus of this research is to use the microgravity environment to study a broad range of physical phenomena. The research spans from the basic to the applied, and will continue to impact both the scientific communities of which the research is a part as well as industry. As a result of the rigorous peer review of this research, important discoveries have been made in fields ranging from the wetting and spreading dynamics of fluids on surfaces to relativity and precision clock experiments. Moreover, many of the space flight experiments that flow from this program require the unique microgravity environment that is provided by the ISS and thus make use of a national asset that has been very costly to create. Ending the physical sciences research will squander the investment made in building the physical sciences research program and negatively impact the ability to perform high quality research on the ISS.

Just as important as this past investment is the likely impact of the physical sciences program on the future of NASA's human exploration effort. A vibrant physical sciences research program is the key to successfully accomplishing the President's Vision for Space Exploration, since important technology required for space exploration is controlled by gravitationally related phenomena that are poorly understood. This lack of understanding hampers the design of a vast array of devices such as those for heat transfer, the prevention and detection of fires, fluid handling, controlling the transport and movement of Lunar and Martian soils, and materials repair such as brazing and welding, among many others. The need for research in these areas is discussed in detail in the NRC report "Microgravity Research in Support of Technologies for the Human Exploration and Development of Space and Planetary Bodies." Given the central importance of these areas in fostering the human exploration of space effort, the impact of a physical sciences research program on one of NASA's central missions could thus be profound. As illustrations, I shall focus on two such examples: heat transfer systems and fire prevention and detection.

Thermal control is critical for spacecraft; excess heat must be rejected into space and moved from one section of the craft to another. In the past NASA relied on single-phase heat transfer systems, for example systems that involve only a liquid to transfer heat. However, there are clear advantages of employing systems that involve both a liquid and vapor (two phases), such as those used on the earth. This allows one to employ the significant amount of heat required to transform a liquid to a vapor or a vapor to a liquid in the heat transfer process. This significant heat of vaporization or condensation allows the heat to be transferred in a far more efficient manner than with a single-phase system. The successful operation of such systems on the earth frequently requires that the less dense vapor sit above the more dense liquid which, due to the presence of gravity, occurs naturally in a terrestrial environment. However this density driven stratification would not be present in space. This is but one of the many challenges of using such systems in space. Nevertheless, the advantages of using such a system in a spacecraft are significant. Given the enhanced efficiency, a multiphase heat transfer system would save considerable space and mass. Heat pipes have also been proposed as possible heat transfer devices. These have the advantage of being completely passive where the motion of the fluid is driven by the surface tension of the liquid, but they also involve evaporation and condensation to transfer heat.

The central reason why heat transfer systems that involve multiphase flow are not more commonly used in spacecraft is that the dynamics of flow in systems with more than one phase, such as a vapor and liquid, in a microgravity or partial earth's gravity environment are not well understood. A ground-based and flight program focused on the dynamics of flow in these multiphase systems could provide the insights to allow these higher efficiency devices to be used in the human spaceflight effort. While there are constraints on the mass and space available in the limited-duration environment of the Shuttle or ISS, the constraints placed on long-duration flights to Mars or even the Moon are even more stringent. Thus, the availability of high efficiency heat transfer devices, that occupy less space and have a smaller mass than existing devices, would open up much needed space for food and water. It is only through research in this area that these devices will be embraced by the spacecraft engineering community.

A second example of the importance of physical sciences research is in preventing and detecting fires in a reduced gravity environment. We have had thousands years of experience detecting and fighting fires on Earth. In contrast our experience with combustion phenomena in microgravity or partial Earth's gravity is limited to at most fifty years. As a result, our understanding of the flame propagation issues that impact spacecraft safety is very limited, and research in this area continues to uncover new and unexpected results. For example, flames can spread along surfaces in the opposite direction to that on earth, flames extend over electrical insulation 30 to 50 percent faster in microgravity than under normal conditions, and smoldering under microgravity conditions is less bright and more difficult to detect than on the ground. All of these results were determined from basic research conducted in only the past 10 years and have had a documented effect on the fire fighting procedures on spacecraft. Given the limited number of experiments performed in microgravity and the surprising results thus produced, there is much still to be learned.

Although fires on a space craft are an unlikely event, if one should occur it could be catastrophic not only for the mission but for the entire human exploration of space effort. The absence of any safe refuge on a spacecraft and, possibly, lunar base makes detecting and preventing small fires essential. Moreover, the design of lunar habitats that mitigate the effects of possible fires requires knowledge of how fires propagate in structures in partial Earth's gravity. Physics based simulation codes exist for fires in Earth-based structures, but none exist for micro or partial gravity environments. Given our lack of understanding of how fires behave in microgravity environments and the critical importance of this to the human exploration effort, I can think of few stronger rationales for a vigorous combustion research program. Such a program must involve an active ground-based program and, due to the long duration of many combustion experiments, ready access to the ISS may be required.

Going Forward

In order to leverage the past investment in physical sciences research and to ensure a successful future for the human exploration effort it is crucial that a broad spectrum of physical sciences research in NASA be retained. The importance of continuity in a research program cannot be overemphasized. Continued support of this community is essential in engaging the best researchers, producing the students interested in working with NASA upon graduation, and performing the ground-breaking research that is essential to accomplishing NASA's human spaceflight goals. The level of support needed for this continuity is quite modest given that a cadre of 250 investigators each of whom requires $130K would lead to a $32.5M per year program, a very small investment compared to the $1B of the former Office of Biological and Physical Research. This represents the minimum support needed to keep a physical sciences research program alive at NASA. Many researchers have recently had their programs terminated. If this support is not made available in the very near future these scientists will be reluctant to return to microgravity research and the remaining researchers will also likely leave the program. As a result NASA will find itself in the same position as it was in the late 1980s: without an organized and influential microgravity research program. Unfortunately, NASA will never have the time or the resources to recreate a physical sciences research community. Therefore it is absolutely imperative that NASA fund physical sciences research at no less than $32.5M for FY07.

To avoid many of the pitfalls of the past, it is essential that the program involves both ground-based research and spaceflight experiments. One of the crucial lessons of the early microgravity program is that only through the testing and refinement that is possible with ground-based theoretical and experimental research can experiments be performed in space that will yield reliable results. It is essential that both the ground-based and spaceflight research be rigorously-peer reviewed.

The future of research at NASA is being threatened as never before. It is important to realize that funding physical sciences research will not diminish in any way NASA's future plans for human exploration. Rather it will be an essential enabler in this effort. Finally, continuation of the funding will allow NASA to reap the benefits of many past years of funding of high impact research that is focused on gravitationally related phenomena.

Thank you very much for the opportunity to testify today. I look forward to responding to your questions.

The NASA Workforce: Does NASA Have the Right Strategy and Policies to Retain and Build the Workforce It Will Need

House Science Committee
June 13, 2006

Statement of
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President and CEO
Universities Space Research Association
and
Adjunct Professor
Physics and Astronomy Department
Rice University

Mr. Chairman, Ranking Minority Member, and committee members: I appreciate the opportunity to testify before you today. My name is David Black. I am the President and CEO of the Universities Space Research Association. The Universities Space Research Association was incorporated in 1969 in the District of Columbia as a private, nonprofit corporation under the auspices of the National Academy of Sciences (NAS). Institutional membership in the Association has grown from 49 colleges and universities when it was founded, to the current 100 institutions. All member institutions have graduate programs in space sciences or technology. Besides the 92 member institutions in the United States, there are two member institutions in Canada, three in Europe, two in Israel, and one in Australia. USRA provides a mechanism through which universities can cooperate effectively with one another, with the government, and with other organizations to further space science and technology, and to promote education in these areas. I am also an Adjunct Professor in the Physics and Astronomy Department at Rice University.

I appear today largely in my capacity as co-chair of the National Research Council (NRC)'s Committee on Issues Affecting the Future of the U.S. Space Science and Engineering Workforce. The NRC is the operating arm of the National Academy of Sciences, National Academy of Engineering, and the Institute of Medicine of the National Academies, chartered by Congress in 1863 to advise the government on matters of science and technology. The views expressed in my testimony today are in part those expressed by the NRC Committee in its Interim Report, as well as my own. I shall do my best to make clear which views are mine and which are those of the Committee. The latter views are fully supported by my co-chair of the NRC study, Dr. Daniel Hastings, who is Dean for Undergraduate Education and Professor of Aeronautics and Astronautics at MIT.

Prior to addressing the specific issues on which you have asked me to comment, allow me to provide some context for the NRC Committee's activity. I should note that the Committee has completed most of our fact-finding and will be preparing our final report near the end of the calendar year. As such we are not yet prepared to provide a complete set of recommendations but expect to do so in our final report.

The NRC Committee's charge from NASA is to explore long-range science and technology workforce needs to achieve the nation's long-term space exploration vision, identify obstacles to filling those needs, and explore solutions for consideration by government, academia, and industry. The specific tasks that we have been requested to undertake are the following:

1. Assess current and projected demographics of the U.S. aerospace engineering and space science workforce needed to accomplish the exploration vision;
2. Identify factors that impact the demographics of the affected workforces;
3. Assess NASA's list of the workforce skills that will be needed to implement the Vision for Space Exploration, both within the government and in industry;
4. Identify the skills needed to implement NASA's Vision for Space Exploration within the academic community;
5. Assess the current workforce against projected needs;
6. Identify workforce gaps and analyze obstacles to responding to the workforce needs, and in particular, analyze the proper role of academia and the obstacles to achieving this proper role; and
7. Develop recommendations for specific actions by the federal government, industry, and academia to address those needs, including considerations such as organizational changes, recruiting and hiring practices, student programs, and existing workforce training and improvement.

The NRC Committee has drawn upon input from two workshops and documents provided by NASA to arrive at the following preliminary findings:

1. NASA has made a reasonable start on assessing its near- and long-term skill needs, and the Committee shares the view expressed by NASA representatives that there is still much more work to be done. However, NASA's work has focused on initial assessment of current workforce demographics and estimates of future needs, and at the time of the NRC's interim report NASA had not yet translated that analysis into a strategy and action plan.
2. NASA needs a strategic workforce plan that deals with the next five years and that lays the foundation for a longer-term process. This will be a new and difficult process for NASA, but it will nevertheless be vital for the agency's success in implementing the space exploration vision.
3. The Committee has not seen compelling evidence for a looming, broadly based shortage in the supply of aerospace science and engineering workforce employees to meet NASA's needs. (This is not to say, however, that the committee disagrees with the broader issues about the adequacy of the U.S. science and engineering workforce.) However, the committee believes that in order to continue to have an adequate supply of these employees, it is important that NASA provide adequate funding for university based research programs and flight opportunities. This will help ensure that universities continue to sustain curriculum, faculty, and student interest in the aerospace sciences and technologies.
4. To address those skill areas where there are concerns (both for the near term and the longer term), NASA needs to pay particular attention to identifying and expanding ways to promote exchanges of personnel between NASA and the private sector (industry, academia, and non-government organizations).
5. The degree to which the agency chooses to perform work in-house versus by a contractor will play a major role in the number of personnel that the agency will require.
6. The Committee concludes that the ability to recruit and strategically retain the needed workforce will depend fundamentally on the perception of long-term stability of the Vision for Space Exploration and a sustainable national consensus on NASA's mission.

As a result of these findings the NRC Committee made the following recommendations:

1. NASA should develop and publicize a workforce strategy for ensuring that it is able to target, attract, and retain the skilled personnel necessary to implement the space exploration vision and conduct its other missions in the next five to 15 years.
2. NASA should adopt innovative methods of attracting and retaining its required personnel and should obtain the necessary flexibility in hiring and reduction-in-force procedures, as well as transfers and training, to enable it to acquire the people it needs. Transfers within the agency could fill many needs if coupled with appropriate training. NASA should work closely with the DoD to initiate training programs similar to those that the DoD initiated, or otherwise participate actively in the DoD programs.
3. NASA should expand and enhance agency-wide training and mentorship programs, in order to develop or improve needed skills within the existing workforce. For example, NASA could provide some of its employees opportunities for gaining on-the-job experience for its most vital required skill sets such as systems engineering.

As you can see, the NRC Committee has made reasonable progress, but much work remains to address fully the charge that we have been given. That said, let me turn to the questions your committee has posed to me.

What are the critical skills that will enable NASA to complete its goals in space and earth science, aeronautics, and exploration?

Although the Committee has not reviewed NASA's critical skill needs on an item-by-item basis, it is likely that the agency will need to maintain at least a small core of employees having skills in the majority of the same areas that the agency has depended upon throughout its history. Individuals with skills and experience in project management and systems engineering will be particularly critical to successful realization of NASA's goals. The NRC Committee intends to examine this issue in more detail in our final report after we have had a chance to evaluate the material that NASA has provided to our Committee. We recognize that this is a daunting task for NASA as it starts with essentially a blank piece of paper. The NRC Committee's initial reaction to NASA's work done so far is that it is incomplete and reflects a top-down view of what skill mixes are needed and as such is more theoretical than empirical.

An essential aspect of any answer to this question is the "make/buy ratio" that NASA decides to implement, i.e. the division of responsibilities for work to be done by the agency's field center employees vs. work to be done by outside contractors. I will comment more specifically on the role of this ratio below, but let me just say here that clearly the demands on NASA's in-house workforce will be lessened if this ratio is low, as some of the requisite skill base can then reside external to the agency.

What decisions must NASA make now to prepare for its future workforce needs?

The NRC Committee has identified several key decisions that NASA faces, and there are sure to be others that will become clear as we complete our study. In the view of our Committee, the most critical decision is the one just discussed, the amount of work done by NASA employees relative to that done in academia and industry. The extent to which NASA decides to develop and operate space systems in-house at its field centers or to contract such work out will have a substantial influence on the skills needed in-house. Moreover, such make/buy decisions also have a strong influence on recruitment of future NASA employees.

Furthermore, NASA needs to determine what means it will use to ensure that prospective employees, entering jobs either inside the government or in the private sector, gain the requisite training and experience in those critical areas that are needed to fulfill the agency's goals and objectives. NASA does have training and mentorship programs, and I should say parenthetically here that my organization has been working with NASA to expand these over the past years, but in general these programs are modest in scope and impact.

NASA also will need to make decisions regarding how it can provide assurance, or perhaps more on point, a sense of "hope and promise" to potential future members of the agency's workforce. Twenty years ago, the mere mention of NASA was an attractor. It had vocational pizzazz. That is no longer the case. Considerable publicity is given to NASA projects that are delayed or cancelled, and there are fewer opportunities for NASA staff to be engaged in meaningful science and engineering. I am concerned that many of the best and brightest young people are attracted to the science part of what NASA does, but the inability of the Administration and Congress to properly fund NASA's implementation of the Vision for Space Exploration will mean that support for science will erode. The research advisors in the academic disciplines associated with these science areas won't have the funding to support the best and brightest graduate students, who may go elsewhere. The ability of NASA to develop ways to reinvent itself in the sense of attracting the best and brightest in its science and engineering competencies is very important.

Finally, NASA will need to decide how much critical mass of expertise should be sustained in key areas such as microgravity life and physical sciences. It is easy to turn off communities with budget decisions, but it is not as easy to turn them on in a timely manner at some point in the future. The employment ecosystem extends from NASA and other similar technical employers through universities and arguably down to high schools. The life scientists needed to do cutting edge research in 2015 are in high school today. How likely are they to choose career paths that would take them to NASA in light of recent decisions to minimize that field of work? A related aspect is that the university community that is the source of NASA's future workforce is already showing signs of steering their best students to other career paths because NASA commitments appear to be uncertain or unstable.

Does NASA's workforce strategy fulfill the needs identified by the NRC interim report?

Our Committee has not had a chance to review NASA's new workforce strategy, but will do so as the NRC study moves ahead during this year. The Committee's interim report does suggest a number of important elements that should be included in such a strategy. They include an analysis of future skill needs, both in terms of types of skills and numbers of employees, that is then linked to plans for recruitment and training to meet those needs, as well as plans for partnerships with industry, other government agencies, and academia to meet future training needs.

What are the tradeoffs associated with completing work in-house at NASA or contracting them out?

Our Committee has not yet addressed this question thoroughly, so I will have to give you what is largely my personal view at this point. As remarked earlier, the Committee does feel that this tradeoff is one of the more critical, if not the most critical, decision that NASA must make. Whether or not there is strong reliance on external organizations, NASA must retain a cadre of expert engineers and scientists on its own staff. Administrator Griffin has made the point that NASA needs to be a smart buyer, and that requires skilled and knowledgeable employees who are involved with buying decisions and in program management. Recent experience in the DoD indicates that when the government expertise in national security space was allowed to wane, the government made major mistakes in what and how it contracted with industry.

If the decision is to buy rather than build, NASA will not need a large number of people with the requisite skills, but those on whom they rely must be exceptionally skilled and experienced. Choosing a path that emphasizes buying what is needed allows NASA to tap into a skilled workforce that is already largely in place, and which is unencumbered by civil service hiring and firing rules. This latter aspect makes it easier to adjust the workforce as budgets, and program schedules, wax and wane. Selection of the buy path also expands the support base for NASA's programs in a political sense, as employees of companies and universities beyond the NASA field centers have a vested interest in the success of those programs. However, it is important to realize that NASA can never give up the core of talented people necessary to be "smart" buyers. NASA needs to retain enough in-house projects to develop and retain these smart buyers or facilitate exchange with industry to get smart buyers with current experience.

Conversely, should NASA opt to place more emphasis on building what is needed using an in-house workforce, they will need to recognize that in next five years or so, they will have gaps in necessary expertise that cannot be rapidly filled by training current in-house people or by inexperienced new hires. The NRC Committee has examined this issue, and the Committee concludes that ways must be found for NASA to supplement its present workforce with members of industry, the retiree community, and academia who do currently possess the skills required.

The situation for the longer term will depend upon NASA's ability to train in-house staff and to establish an environment that encourages the brightest young students to seek employment with NASA. A key element of this will be to provide opportunities within universities for meaningful hands-on training and experience for students. Data on the trend of NASA-sponsored opportunities of this type show a clear decrease over the past three decades or more (see Figure 1), and a projection into the future given the proposed budgets suggests that this decrease is likely to continue. The knowledge needed to become a skilled project manager is not found in a textbook or classroom; it comes from doing the work and experiencing failures as well as successes. A "build" as contrasted to "buy" approach will allow NASA to offer its employees compelling challenges, which is an important ingredient in making employment with the agency attractive to young people. However the most effective, and perhaps even essential, approach to meeting the needs of both the federal government and industry for people with hands-on experience will be to nurture and expand ways to begin to provide that experience while science and engineering students are still in universities. As a companion NRC study committee recently recommended, that will require reversing the trend of declining opportunities for programs that do provide the hands-on experiences.

In closing my prepared remarks Mr. Chairman, I would note that the NRC Committee feels strongly that NASA needs to look outside of itself in assessing the nature, scope, and possible solutions for its skill mix. NASA has historically been a "can-do" agency, but also one afflicted to some extent with the "not invented here" syndrome. The issues NASA faces in terms of workforce are national in character; they reverberate through other government agencies involved in space-related work, as well as the private sector including universities. NASA should not, in our Committee's view, try to structure a solution in isolation from consultation with the broader set of communities noted above. While we have not formulated a recommendation in this area, I believe I can speak for many people in saying that the nation's space programs would benefit if the issue of workforce is addressed by involving the representatives of the workforce ecosystem in both the assessment of the problem and the range of possible solutions.

I would be happy to expand on my remarks or address additional questions should you wish.

Thank you again for the opportunity to share with your committee the perspectives on this important issue that the NRC Committee has developed in this early stage of our work.

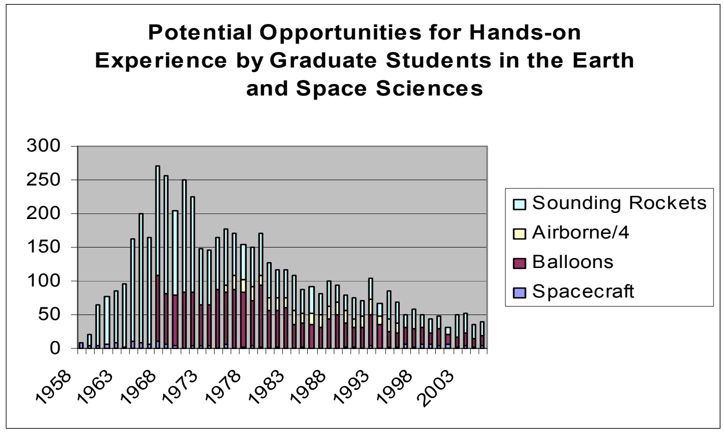

Figure 1. History of opportunities for student hands-on participation in sub-orbital flight experiments and small space missions in Earth and space science.

SPACE STUDIES BOARD NEWS

New Board Members

The National Research Council has provisionally approved the appointment of seven new members to the Space Studies Board. The terms of 11 of the 26 members of the Board expire on June 30, 2006. In an effort to standardize the length of Board terms and to provide additional flexibility in determining Board composition, all new Board terms will be for two years (instead of the current mix of 3-year and 1-year terms). Two SSB members were reappointed: Lennard Fisk as chair, and Tamara Jernigan. A. Thomas Young, who already was a member of the Board, will serve as vice chair. The seven new members are: Steven Battel, Charles Bennett, Jack Fellows, Kenneth Nealson, James Pawelczyk, Joseph Veverka, and Warren Washington. Effective July 1, 2006, the 24 members of the Space Studies Board are shown on the next page. Additional biographical information is available on our website.

SSB Summer Interns

Ms. Stephanie Bednarek, our 2006 Space Policy Intern, is a rising fourth year student at the University of Virginia (UVA). She is working toward her Bachelor of Science degree in Aerospace Engineering with a minor in Astronomy. This summer she is working with her SSB advisor, David Smith, on a variety of active SSB projects, including the Lunar Science Strategy study. Over the past few summers, Stephanie has worked as an intern with Aerospace Industries Association and Orbital Sciences Corporation. At UVA, she serves as the Student Director of Engineering Visitation and Undergraduate Recruitment and

Secretary of UVA's American Institute of Aeronautics and Astronautics student chapter. In addition, she is the Vice President of Virginia's Equestrian Team and a member of Alpha Delta Pi sorority. After graduation in May 2007, she plans to attend graduate school to study science and technology and policy and pursue a career in space policy.

Mr. Brendan McFarland, our SSB summer undergraduate intern, will be a junior at Johns Hopkins University pursuing a major in Physics with a minor in Mathematics. His scientific interests lie mostly within Astronomy and Astrophysics, including, but not limited to, cosmology, pulsars, and black holes. When not occupied by his academic pursuits at school, he enjoys broadcasting his radio show on the student-run radio station. He anticipates applying to graduate school in astronomy and attaining an advanced degree in the field. He hopes to one day become directly involved in our nation's space policy process.

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