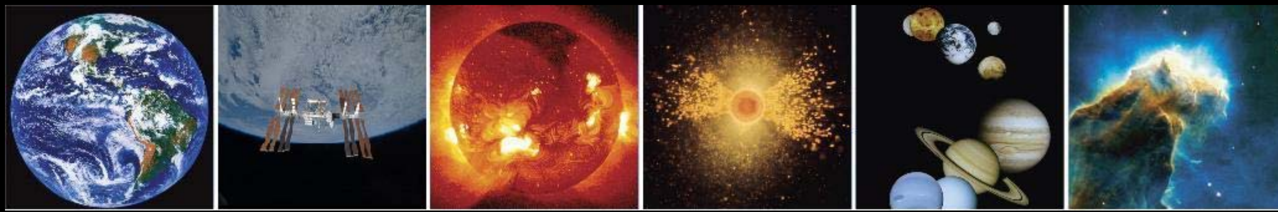
SPACE STUDIES BOARD NEWS



APRIL—JUNE 2010

INSIDE THIS ISSUE

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—Charles F. Kennel, Chair, SSB

APRIL—JUNE 2010

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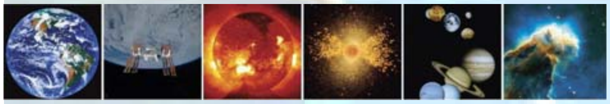

FROM THE CHAIR

I wear two hats these days. I am your Space Studies Board (SSB) Chair, and I also chair the California Council on Science and Technology (CCST). CCST, which is modeled on the National Research Council, provides advice on science and technology (S&T) to the government of the state of California. For the SSB, I get to preside over discussions about what advice to give NASA about its future programs. For CCST, I preside over discussions about what science and technology can do for the people and economy of the state, and what the state could do to encourage its S&T community.

On May 17, 2010, the California legislature, in a bill sponsored by 13 members from both the Assembly and the Senate and from both sides of the aisle, asked CCST to undertake a comprehensive study of "California's science and technology (S&T) innovation infrastructure and 'ecosystem,' analyzing and reporting current global innovation systems, and recommending to the Legislature actions that should be taken to sustain the state's role as a global leader in science and technology."

This is a pretty tall order, but the first step is always the hardest. We had no trouble taking it. On May 25, CCST and the California Space Authority co-sponsored "Space Day" in Sacramento, which was kicked off by a highly popular screening of "Hubble 3D" in the IMAX Sacramento Theater across from the Capitol, and continued the next day with CCST discussions of California's space economy. In a state that is home to Silicon Valley and two of the world's great biotechnology centers, it is significant that CCST started its study of innovation with space.

By any measure, California is the largest aerospace state in the country. Three of NASA's centers are located in California and 20 percent of NASA's budget is spent in California. The Defense Space Command is located in California, as are numerous aerospace firms, large and small. The California Space Authority estimates that aerospace companies and suppliers located in California employ at least a half a million people.

Let's look at what NASA centers do in and for California. The Jet Propulsion Laboratory, with about 5,000 employees, is the world's leading center for interplanetary space missions and, along with Goddard Space Flight Center, a leader of NASA's Earth science programs. The Ames Research Center, with about 1,200 civil servants, is NASA's portal in Silicon Valley. Its job and its destiny is to capture ideas created in the valley, turn them to NASA's benefit, and in turn stimulate innovation in the companies nearby. Ames manages NASA's Astrobiology Institute (no accident), which is designing innovative robotic precursor missions for deep space exploration and is innovating small satellite subsystem technologies. Dryden Flight Research Center (about 550 civil servants), NASA's experimental flight support facility, is becoming a center of innovation too, as the region surrounding Edwards Air Force base, where Dryden is located, has become home to a cluster of entrepreneurial aerospace firms building next generation space vehicles.

"...we have learned that California and NASA need each other. NASA's intellectual network extends beyond its centers directly into the heart of its surrounding science and technology communities."

Why should non-Californians pay any attention to all this? Perhaps it is because we have learned that California and NASA need each other. NASA's intellectual network extends beyond its centers directly into the heart of its surrounding science and technology communities. NASA both draws on and stimulates the communities in which it lives. NASA's challenging goals attract a special kind of person, and its unusual programs prompt the development of new knowledge and inventions. No one of the NASA centers could do its work without the talented people who specialize in communications, sensors, robotics, materials, nanotechnology, biotechnology, propulsion, human factors, and many other things.

Of course, CCST is not the first to recognize that having a NASA program is good for regional economic development. But too many people view NASA's presence solely in terms of the number of jobs at a NASA center or the number employed on NASA contracts and grants.

NASA is not, repeat not, a jobs program. Look at the numbers. NASA's direct employment is not more than 10,000, yet the California Space Authority estimates there are half a million people working in aerospace in California. Many people cite the technological fallouts from NASA work, but even that, I think, undersells NASA. I view NASA as a goals and talent program that animates and energizes the regional knowledge networks around it.

So what should the states and countries angling to supplant California's leadership in space do? Invest in education and build communities of talent. Build them, and space leadership will come.

—Charles F. Kennel, Chair, Space Studies Board

DIRECTOR'S CORNER

The first couple of months on the job as director of the board have been busy. With the astronomy and astrophysics decadal survey in its final stages of preparation for release, the surveys of planetary science and biological and physical sciences in space preparing to enter their final phases, and the decadal survey on solar and space physics getting underway, we are probably at a peak of decadal activity for the space sciences community. In addition the SSB has just released three reports: an interim report from the decadal survey on biological and physical sciences in space (*Life and Physical Sciences Research for a New Era of Space Exploration: Interim Report*); and final reports on cost growth in NASA Earth and space science missions (*Controlling Cost Growth of NASA Earth and Space Science Missions*); and an assessment of NASA laboratory capabilities (*Capabilities for the Future: An Assessment of NASA Laboratories for Basic Research*), a study led by the NRC's Laboratory Assessments Board and carried out with the Aeronautics and Space Engineering Board and the SSB.

The committee that authored *Capabilities for the Future* was tasked to determine whether the laboratories are equipped and maintained to support NASA's fundamental research activities. The study found that several changes since the mid-1990s have had a significant adverse impact on NASA's funding for laboratory equipment and support services, and that as a result the innovation and technologies required to advance aeronautics and space research have been severely restricted by a short-term perspective and funding. The report also notes that despite all the challenges the agency laboratories face, the NASA researchers encountered by the committee remain dedicated to their work and focused on NASA's future. The committee believes that NASA could reverse the decline in laboratory capabilities by restoring the balance between funding for long-term fundamental research and technology development and short-term, mission-focused applications. The situation could be significantly improved if fundamental long-term research and advanced technology development at NASA were managed and nurtured separately from short-term mission programs. More information on this report can be found in this newsletter and on the SSB Web site.

"The workshop is based on the premise that as it continues to pursue answers to these questions, it is essential that NASA conveys to the general public an understanding of and an appreciation for this quest for knowledge. "

In *Life and Physical Sciences Research for a New Era of Space Exploration: Interim Report*, the committee provides some timely input to the ongoing reorganization at NASA of programs related to life and physical sciences microgravity research, as well as to near-term planning or re-planning of research on the International Space Station (ISS). Although the development of specific recommendations is deferred until the final report, this interim report attempts to identify programmatic needs and issues to guide near-term decisions that the committee has concluded are critical to strengthening the organization and management of life and physical sciences research at NASA. The report notes that as the result of major reorganizations and shifting priorities within the past decade at NASA, there is currently no clear institutional home within the agency for the various scientific endeavors that are focused on understanding how biological and physical systems behave in low-gravity environments. As NASA moves to rebuild or restructure programs focused on these activities, the agency, the report notes, will have to consider what elements to include in that program, and the committee provides a preliminary analysis of a number of critical needs for a successful renewed research endeavor in life and physical sciences. In addition the interim report notes that the ISS provides a unique platform for research, and while it is difficult to predict the timing for the transition of important research questions from ground- to space-based investigations, the committee identifies in this interim report a number of broad topics that represent near-term opportunities for ISS research. More information is also available online and within this newsletter.

The SSB report *Controlling Cost Growth of NASA Earth and Space Science Missions*, which was sponsored by NASA's Science Mission Directorate, reviews the body of existing studies related to NASA space and Earth science missions and identifies the key causes of cost growth, as well as strategies for mitigating cost growth. The report assesses whether those key causes remain applicable in the current environment, identifies new causes, and comments on the effectiveness of current NASA cost-growth-mitigation strategies. As stated in its report, the committee generally concurs with the consensus viewpoints expressed in the studies it considered. But the committee notes that the studies use initial estimates made at different points in mission life cycles as well as cost estimates that cover different phases of mission life cycles. These differences make it very difficult to derive a single, reliable value for the average cost growth of NASA space and Earth science missions on the basis of previous studies. The primary references the committee reviewed identify a wide range of factors that contribute to cost and schedule growth, with those most commonly identified factors being the following: overly optimistic and unrealistic initial cost estimates; project instability and funding issues; problems with development of instruments and other spacecraft technology; and launch service issues. Finally the report recommends that NASA adopt a comprehensive, integrated cost containment strategy. Again, more information is available online and within this newsletter.

Our attention is also focused on activities planned for this

(Continued on page 4)

SSB MEMBERSHIP

JULY 1, 2009—JUNE 30, 2010

CHARLES F. KENNEL, *CHAIR*
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Lockheed Martin Corporation (ret.)

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Aerospace Consultant

ELIZABETH R. CANTWELL
Oak Ridge National Laboratory

ANDREW B. CHRISTENSEN
Dixie State College and The Aerospace Corporation

ALAN DRESSLER
The Observatories of the Carnegie Institution

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University Corporation for Atmospheric Research

FIONA A. HARRISON
California Institute of Technology

JOAN JOHNSON-FREESE
U.S. Naval War College

KLAUS KEIL
University of Hawaii at Manoa

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BERRIEN MOORE III
Climate Central, Inc.

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JAMES PAWELCZYK
Pennsylvania State University

SOROOSH SOROOSHIAN
University of California, Irvine

JOAN VERNIKOS
Thirdage, LLC

JOSEPH F. VEVERKA
Cornell University

WARREN M. WASHINGTON
National Center for Atmospheric Research

CHARLES E. WOODWARD
University of Minnesota

ELLEN G. ZWEIBEL
University of Wisconsin, Madison

LIAISON

U.S. REPRESENTATIVE TO COSPAR
EDWARD C. STONE
California Institute of Technology

JULY 1, 2010—JUNE 30, 2011

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University of Minnesota

THOMAS H. ZURBUCHEN
University of Michigan

LIAISON

U.S. REPRESENTATIVE TO COSPAR
ROBERT P. LIN
University of California, Berkely

For more information on the membership of the SSB please visit our website at <www.nationalacademies.org/ssb>.

Director's Corner
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fall. The SSB fall meeting will be based around a workshop to be held at the Arnold and Mabel Beckman Center in Irvine, California, on November 8-10. The workshop theme is Sharing the Adventure with the Public—The Value and Excitement of "Grand Questions" of Space Science and Exploration. The grand questions referred to here are those that have driven NASA science and exploration programs in the past and will continue to do so in the future. The workshop is based on the premise that as it continues to pursue answers to these questions, it is essential that NASA conveys to the general public an understanding of and an appreciation for this quest for knowledge. The workshop will bring together leading scientists and communications specialists to share lessons learned and discuss potential future approaches for such outreach. The National Research Council will produce a report summarizing the discussions that take place. (See page 18 of this newsletter for the meeting announcement and workshop Web site, where further details can be found.)

It is certainly turning out to be a busy year for the SSB, and the summer is going to be anything but quiet.

—Michael Moloney, Director, SSB and ASEB

SSB STANDING COMMITTEE CHAIRS

COMMITTEE ON ASTRONOMY AND ASTROPHYSICS (CAA)*

COMMITTEE ON EARTH STUDIES (CES)
Chair: Berrien Moore III
Vice Chair: Ruth S. DeFries

COMMITTEE ON THE ORIGINS AND EVOLUTION OF LIFE (COEL)**
Co-Chairs: Robert T. Pappalardo and J. Gregory Ferry

COMMITTEE ON PLANETARY AND LUNAR EXPLORATION (COMPLEX)***

COMMITTEE ON SOLAR AND SPACE PHYSICS (CSSP)***

*Joint with the Board on Physics and Astronomy; on hiatus during the Astro2010 decadal survey.
**Joint with the Board on Life Sciences.
***COMPLEX and CSSP are on hiatus during the planetary science decadal survey and the solar and space physics decadal survey.

SSB ACTIVITIES

THE BOARD AND ITS STANDING COMMITTEES

The **Space Studies Board (SSB)** did not meet during this quarter. The next SSB meeting will be on November 8-10, 2010, at the National Academies' Arnold and Mabel Beckman Center, in Irvine, CA, and will include a workshop on Sharing the Adventure with the Public –The Value and Excitement of "Grand Questions" of Space Science and Exploration (see more information on page 18 of this newsletter.

The **Committee on Astronomy and Astrophysics** (**CAA)** is on hiatus until the completion of the astronomy and astrophysics decadal survey.

The **Committee on Earth Studies (CES)** did not meet in this quarter; however, a meeting of the committee was scheduled for July 7-8, 2010, in Washington, DC. Agenda items for this meeting include briefings by NASA, NOAA, and USGS officials on the implementation of the decadal survey in Earth science and applications from space and the implications of a major restructuring of the NPOESS program for climate-related measurements, including continuity of climate data records. As is customary, the committee will also meet with agency officials to discuss issues of mutual interest, including potential NRC studies or workshops.

The **Committee on the Origins and Evolution of Life (COEL)** held its second meeting of 2010 at the National Academies' Keck Center in Washington, DC, on June 3-4. The main focus of the meeting was a series of presentations and discussions on virtual institutes—their role, operation, and criteria for success. For the last several meetings, the committee's activities have focused on the initiation of a study concerning the planetary protection requirements for spacecraft missions to the icy bodies of the outer solar system. A formal request to initiate such a study was received from NASA on May 20. An ad hoc committee will be assembled to address this task. The committee's third and final meeting in 2010 will take place at the National Academies Jonsson Center in Woods Hole, MA on October 13-15.

The **Committee on Planetary and Lunar Exploration (COMPLEX)** is on hiatus until the completion of the planetary science decadal survey.

The **Committee on Solar and Space Physics (CSSP)** is on hiatus until the completion of the solar and space physics (heliophysics) decadal survey.

STUDY COMMITTEES

The ad hoc **Committee on the Assessment of Impediments to Interagency Cooperation on Space and Earth Science Missions** completed a final draft of its report. The report will enter external peer review in July 2010.

The final report of the **Committee to Assess NASA's Laboratory Capabilities**, a study carried out by the Laboratory Assessments Board in collaboration with SSB and ASEB, was submitted to the sponsor, NASA, on April 28. The public version, entitled *Capabilities for the Future: An Assessment of NASA Laboratories for Basic Research*, was issued on May 11. Briefings were provided during the month of May to NASA, House and Senate staffers, the Office of Science and Technology Policy, and the Office of Management and Budget.

The report of the **Decadal Survey on Astronomy and Astrophysics (Astro2010)** is currently in review and is expected to be released in prepublication form later this summer. Check the survey's webpage at www.nationalacademies.org/astro2010 for further updates through August.

The steering committee for the **Decadal Survey on Biological and Physical Sciences in Space** met on March 31 to April 2, 2010, in Irvine, CA, to draft an interim report that would identify both organizational and management issues important to the success of the life and microgravity research enterprise at NASA and near-term research opportunities for the International Space Station. In developing this document, the committee relied heavily on inputs and analyses that had previously been collected or performed as part of the work on the full decadal survey. The steering committee continued work on the interim report following the meeting, and the final draft was submitted to external peer review in early May. Review and editing of the interim report were completed in June and report delivery is planned for early July, with a public release scheduled for mid- July.

The **Decadal Strategy for Solar and Space Physics (Heliophysics)** steering committee will be chaired by Daniel Baker, University of Colorado, and the vice chair will be Thomas Zurbuchen, University of Michigan. Appointments for the rest of the 18-member steering committee were in progress as the quarter ended. Detailed information about the survey is posted at a public website that is available via a link posted at the homepage of the SSB(http://sites.nationalacademies.org/SSB/); or directly at http://sites.nationalacademies.org/SSB/CurrentProjects/SSB_056864.

The ad hoc **Committee on Cost Growth in NASA Earth and Space Science Missions** publically released its report on July 13. The report recommends that NASA develop a comprehensive, integrated strategy to contain cost and schedule growth. The strategy should include recent changes that NASA has already implemented as well as other actions detailed in the report to improve cost realism and the development process.

The **Planetary Science Decadal Survey** charge is to determine the current state of knowledge and identify the most important scientific questions expected to face the community during the interval 2013-2022. During this quarter, the survey's panels held their third and final meetings to discuss and continue crafting their sections for the report. The panel meetings were held on the following dates: Satellites, April 12-14 in Boulder, CO; Mars, April 14-16 in Boulder, CO; Inner Planets, April 21-23 in Boulder, CO; Primitive Bodies, April 26-28 in Knoxville, TN; and Giant Planets, May 5-7 in Boston, MA.

The decadal survey's steering group will hold its final two meetings in Washington, DC, on July 13-15 and August 3-4. The steering group will continue the work of pulling together the panels sections into a cohesive draft report for submission to the NRC reviewers.

The decadal survey's target delivery to NASA and the NSF is the end of March 2011. The presentations from decadal survey meetings, together with meeting summaries and archived webcasts, are available at the survey's website: http://sites.nationalacademies.org/SSB/CurrentProjects/ssb_052412.

OTHER ACTIVITIES

On July 1, Robert P. Lin, a professor of physics of the University of California, Berkley (UCB) and the former director of the UCB Space Sciences Laboratory, took over from Edward C. Stone as the United States representative to the International Council for Science's **Committee on Space Research (COSPAR)**. Dr. Lin was also elected as one of the vice presidents of the COSPAR Council on July 17. Additional information on COSPAR Council elections and COSPAR awards is available later in the newsletter.

Dr. Lin began his physics career at the California Institute of Technology, where he received a B.S. in physics before attending UCB, where he completed his doctorate in physics in 1967. Throughout his tenure at Berkeley, Dr. Lin has explored many diverse research interests, including solar flares and solar cosmic rays; plasma phenomena in the interplanetary medium and the magnetosphere; and lunar, planetary, and cometary studies. Recently, Dr. Lin's research interests have primarily been in high-energy solar physics as principal investigator (PI) for the Ramaty High Energy Solar Spectroscopic Imager (RHESSI) mission (launched in 2002), and for the 3D Plasma and Energetic Particle investigation on the Wind spacecraft (launched in 1994).

In addition to his research at Berkeley, Dr. Lin has participated in the development of numerous NASA missions, including the design and deployment of magnetosphere-observing subsatellites during Apollo 15 and Apollo 16 in 1971 and 1972, respectively. This mission led Dr. Lin and his collaborators to develop the electron reflectometer technique, a unique method of remote surface magnetic field measurement on planetary bodies using the magnetic reflection of electrons. This technique was later applied to the Lunar Prospector and Mars Global Surveyor missions, which created high-sensitivity maps of the lunar and martian crustal magnetic fields. He is currently serving as deputy PI for the Mars Atmosphere and Volatile Evolution Mission (MAVEN).

Dr. Lin has received numerous awards and honors for his work, including the Hale Prize of the American Astronomical Society, the NASA Mars Global Surveyor Group Achievement Award, the NASA Ames Research Center Honor Award, the NASA Goddard Space Flight Center Group Achievement Award, and the NASA Lunar Prospector Group Achievement Award. He is also a recipient of the Docteur Honoris Causa de l'Universite de Toulouse and is a fellow of the American Geophysical Union. He currently serves on the editorial boards of *Space Science Reviews*, *Solar Physics*, and the *Annual Reviews of Astronomy and Astrophysics*.

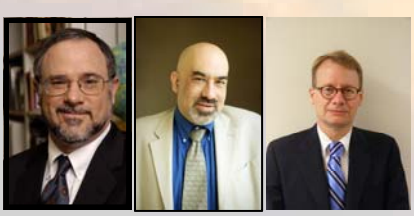
Dr. Lin is a member of the National Academy of Sciences and of the American Academy of Arts and Sciences. He served on the Space Studies Board's Committee on Solar and Space Physics (1995-1997), the Panel on Solar and Space Physics of the Committee on Priorities in Space Science Enabled by Nuclear Power and Propulsion (2004-2005), and the Committee on NASA's Suborbital Research Capabilities (2009-2010).

The **outreach staff** for the Space Studies Board, in conjunction with the Aeronautics and Space Engineering Board, exhibited at the Women in Aerospace Conference held on May 18 in Washington, DC. Women in Aerospace is "dedicated to expanding women's opportunities for leadership and increasing their visibility in the aerospace community." The conference was entitled "Aerospace 2010: Challenges and Opportunities at the Dawn of a New Decade."

SSB BOARD MEMBER NEWS (PAST AND PRESENT)

2010 SHAW LAUREATES IN ASTRONOMY

In May 2010, Space Studies Board members Charles Bennett of Johns Hopkins University (SSB term ending June 30, 2010) and David Spergel of Princeton University (SSB term beginning July 1, 2010), along with Astro 2010 committee member Lyman Page, Jr., of Princeton University, were awarded the Shaw Prize in Astronomy. The award was in recognition of their leadership for the Wilkinson Microwave Anisotropy Probe (WMAP) experiment, which has enabled precise determinations of the fundamental cosmological parameters, including the geometry, age, and composition of the universe.



From l-r: Charles Bennett, David Spergel, and Lyman Page, Jr.

KAVLI PRIZE LAUREATES 2010 IN ASTROPHYSICS

In June 2010 former Space Studies Board member Roger Angel of the University of Arizona, Tucson, Jerry Nelson of the University of California, Santa Cruz, and Ray Wilson, formerly of Imperial College, London, and the European Southern Observatory, share the astrophysics prize for their respective innovations in the field of telescope design that have allowed us glimpses of ever more distant and ancient objects and events in the remote corners of the universe.

From l-r: Jerry Nelson, Ray Wilson, and Roger Angel

Prospects Brighten for Modernization of U.S. Export Controls

Joseph K. Alexander, Senior Program Officer, SSB

U.S. export control laws are intended to prevent proliferation of sensitive technologies and weapons of mass destruction by controlling the export of items that have been defined in law as defense related. The International Traffic in Arms Regulations (ITAR) comprise a key element of those laws, and they include requirements for State Department review and approval of the export of experimental, scientific, and research satellite hardware, technical data, or assistance judged to be defense related.

Although there are specific provisions for excluding fundamental research from ITAR controls, implementation of the regulations has been fraught with ambiguities, uncertainties, and burdens that have frequently complicated or deterred cooperation between U.S. researchers and their international partners in the space sciences. In 2007 the SSB organized a workshop on the implications of ITAR for space science at which State Department regulators and policymakers; academic researchers, faculty, and ITAR officials; NASA officials; and other interested parties explored concerns about ITAR's effects on space science activities. The resulting 2008 report, *Space Science and the International Traffic in Arms Regulations*, summarized the workshop discussions about problems related to ITAR regulations and identified possible steps for addressing or further examining the problems. These issues also were addressed in recommendations in the 2009 SSB-ASEB report *America's Future in Space: Aligning the Civil Space Program with National Needs.*

There have been a number of parallel studies organized by the NRC, the Defense Department, and aerospace industry that have examined the effects of current export controls on U.S. industry and national security. Ensuing discussions between interested stakeholders and officials in both the executive branch and Congress have raised awareness about the problems while steadfastly acknowledging that controlling the export of munitions and sensitive munitions technology remain critically important to national security.

Recent announcements from the Obama administration are beginning to outline a path for modernizing and streamlining the U.S. export control regime, which now is rooted in approaches devised during the Cold War. The current laws are administered partly by the State Department, which is responsible for control of export of militarily sensitive technologies, and partly by the Commerce Department, which administers export of dual-use (i.e., both military and commercial) technologies. Consequently, turf battles and confusion about authority and licensing procedures have often been problems.

Speaking to an industry group in April, Defense Secretary Robert Gates reported on results of an interagency review of export controls. That review made a number of recommendations, including consolidating the current pair of lists of controlled items into a single tiered list, creating a single information technology structure to administer export controls, and creating a single, integrated enforcement center. Then on June 30 National Security Advisor James Jones repeated Gates' points about how current controls often compromise both national security and economic competitiveness. He elaborated on a key feature of the new approach that would consolidate administration of all export licensing under a single new agency whose board of Cabinet-level officials would report to the president.

The administration can take some of the proposed steps on its own via executive orders, and these appear to have good chance of happening. However, the establishment of the new, consolidated export control licensing agency and enforcement center will require congressional approval, and whether or when that will happen remains to be seen. What is clear is that the Defense Department, aerospace industry, and space research community all share the view that changes are badly needed.

Space Weather Protection is a "Team Sport"

Dara Fisher, Space Policy Intern, attended the annual Space Weather Enterprise Forum in Washington, DC on June 8, 2010:

On June 8, 2010, a group of over 200 individuals from academia, industry, and federal agencies gathered for the annual Space Weather Enterprise Forum (SWEF) at the National Press Club in Washington, DC. During this one-day professional meeting, speakers and panelists explored the topic of "Building an Informed and Resilient Society—The Decade Ahead." This meeting came in the wake of a period of increasing solar activity, which may have large implications on the effectiveness of various technologies used across the globe.

The program was organized into four distinct sessions, each of which featured three to four prominent panelists moderated by an individual with significant experience in some aspect of space-weather-hazard mitigation. In each session, the moderator and panel members were given an opportunity to give a short presentation on their area of expertise. After these talks were complete, time was provided for meeting attendees to ask questions or state opinions, either to specific panel participants or to the group as a whole.

The first of these discussions, entitled "A Year Moving Forward—The National Space Weather Program," was meant to serve as a review of advances in the space weather enterprise since the forum held in 2009. During this session, representatives from the National Science Foundation (NSF), the United States Air Force, the National Weather Service (NWS), NASA, and NOAA outlined some of the key space weather projects currently in use and in development, including data-sharing efforts, updates on the STEREO satellite system, the Solar Dynamics Observatory (SDO), radiation belt storm probes, DSCOVR, the Community Coordinated Modeling Center (CCMC), and more.

The next session—"The Future of Space Weather Science and Research Transition to Operations"—was moderated by Louis Lanzerotti, former chair of the Space Studies Board and current professor at the New Jersey Institute of Technology. Discussions during this panel ranged from military space-weather-hazard mitigation efforts through the Air Force Materiel Command and the Naval Research Laboratory to the upcoming NRC heliophysics decadal survey and an update from the Space Plasma Laboratory. Art Charo, study director for the heliophysics decadal survey, announced Dan Baker and Thomas Zurbuchen as the chair and vice chair (respectively) of the upcoming decadal survey, as well as the implications of the 2008 NRC report *Severe Space Weather Events—Understanding Societal and Economic Impacts: A Workshop Report*.

"International Activities and Cooperation," the first of the afternoon panels, was devoted to an examination of the inherently global nature of the threats posed by the upcoming increase in solar activity. Speakers included representatives from the Canadian Space Agency, the European Space Agency, the United Nations Office for Outer Space Affairs, and the U.S. Department of State. Each discussed the importance of space operations and the implications of space weather events to their respective groups. The ESA representative Juha-Pekka Luntama also discussed the new Space Situational Awareness Program, an upcoming ESA endeavor that will address space surveillance and tracking, space weather monitoring, and near earth

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(Space Weather continued from page 7)

object observation.

The final session of the day, "Critical Infrastructure Support," addressed the preparedness level of the United States in the event of a space weather hazard and assessed potential approaches to both raising awareness of the issue and building infrastructure resiliency. Moderated by Dan Baker of the University of Colorado-Boulder, panelists included representatives from the U.S. Northern Command, the House Committee on Science and Technology, and the National Center for Atmospheric Research. The group identified "at risk" elements of the U.S. critical infrastructure in regard to space weather events and discussed response preparedness plans and future inter-agency efforts to address response-planning efforts.

In addition to the panels, three governmental speakers—Representative Donna F. Edwards (D-MD), Jay Reich of the U.S. Department of Commerce, and W. Craig Fugate of the Federal Emergency Management Agency—delivered addresses on how their respective agencies and organizations are addressing the potential threats posed by a space weather event. Each discussed the importance of effective communication between the scientific and governmental communities, with Jay Reich going so far as to discuss the need for social scientists to "translate" scientific issues for the benefit of policymakers.

After all of the discussions at the forum, it was clear that the increased global reliance on GPS and satellite technologies could potentially lead to large-scale problems during the upcoming period of high solar activity. Most participants and panelists advocated for an increase in public outreach by the space weather community in an effort to increase public awareness of and governmental preparedness against potentially damaging space weather events.

Iowa State University's entry into the University Rover Challenge

University Rover Challenge

Andreas Frick, Space Policy Intern, competed in the University Rover Challenge on June 3-5, 2010, as part of the Iowa State University team.

The unforgiving desert near the tiny village of Hanksville, Utah, is not typically on the short list of summer getaway locations for university students. For a handful of students each year, however, it is the ideal location to see years of hard work pay off. This was the case for students of seven university teams who attended this years' University Rover Challenge (URC)—an annual competition for university students to design, build, and operate Mars-analog rovers. The competition, which marked the fourth of its kind, was held from June 3-5. It is hosted by the Mars Society at the Mars Desert Research Station (MDRS), with TASC Inc. sponsoring this year's event. The location offers topography very similar to that of the red planet, which makes it an ideal venue for the student-created Mars rovers to prove their worth. Although effectively negotiating adverse terrain in harsh environmental conditions would prove as the key to success, simply getting to Hanksville with a working rover presented itself as a difficult technological and logistical task (although not necessarily when compared to a journey to the *real* red planet), with only seven teams attending out of originally twelve teams which had registered for the competition. The teams present were Oregon State University, the University of Michigan, Iowa State University, Brigham Young University, the University of Waterloo, and York University from Canada, as well as the Magma team attending from Poland.

The scenario for the URC combines forward-looking, innovative applications for future Mars rovers with tasks mimicking the accomplishments of the highly successful Mars Exploration rovers, Spirit and Opportunity. The competition is comprised of four different tasks. True to the spirit of the Mars Society, some tasks envisioned the rovers as assisting astronauts on a hypothetical future crewed Mars mission (or in preparation thereof), while others targeted more near-term applications for robotic vehicles exploring the planetary surface.

The first challenge was a robotic dexterity task, which requires remotely viewing instructions and performing robotic manipulations on an equipment panel consisting of switches and buttons, as well as plugging in standard power cords into their respective sockets. The entrants were also required to complete a site survey task, which centered on determining accurate coordinates of target markers in a rocky area, some of which were not directly accessible by the rovers. Another task centered on a "hot topic" concerning Mars exploration: a sample return mission, including site prioritization using onboard instrumentation and subsequent testing of the sample for signs of life, such as cyanobacteria or extremophiles. The last task was titled "emergency navigation" and involved delivering an emergency container to a simulated distressed astronaut over difficult terrain and with time of the essence. The exact location of the astronaut would not be known. While the other tasks allowed for teleoperation of the rovers from a tent which was visually isolated from the arena, line-of-sight communications with the rovers were deliberately obstructed by terrain for parts of the last course in order to encourage use of autonomous navigation and obstacle avoidance features.

Since all tasks were timed, some teams resorted to innovative mobility systems to gain speed over their real counterparts on Mars (which only move a few feet per day), while retaining adequate terrain-traversing ability. Oregon State University competed with a highly articulated chassis equipped with six large wheels. Iowa State University uniquely opted for a tracked drive that combined elements of the "rocker bogey" system used on the Mars Exploration Rovers with a flexible belt similar to the treads on a tank but optimized for low weight. Unfortunately, however, reliability became an issue for Iowa State's rover after it incurred some damage to the drive system during the second event, which would haunt the team repeatedly over the course of the competition. Previously, the team's rover spectacularly produced a puff of smoke as some of its electronics for the robotic arm blew out under the desert Sun during the first task. Despite these setbacks, the team was able to at least partially compete in all subsequent events after improvised repairs. Other issues also plagued other teams—University of Michigan was forced to forfeit some events during the first day due to controller issues and York University's rover capsized during its search for the distressed astronaut.

Nevertheless, all teams impressed the judges with their innovation, and sometimes improvisation, in building and maintaining their complex systems with the limited resources and under "real (off-)world" conditions—a valuable skill in spacecraft system design that is difficult to replicate in the classroom alone.

In the end, Oregon State University prevailed to win the 2010 University Rove Challenge with impressive performance in all events, trailed by York University in second place. Closely following was the Magma Team from Poland in third place. Kevin Sloan, the director of the University Rover Challenge, offered concluding remarks, stating that it "challenges students in a way that no textbook or lab ever can. The teams and their rovers have to compete in a difficult range of tasks that demand both broad and deep cross-disciplinary expertise; but more importantly demand a passion and commitment for the work and preparation required. All of the teams have achieved major accomplishments just by bringing working systems to the start line given the short time frame and limited resources allotted."

NEW RELEASES FROM THE SSB

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Capabilities for the Future: An Assessment of NASA Laboratories for Basic Research

This report by the Committee on the Assessment of NASA Laboratory Capabilities is available at http://www.nap.edu/catalog.php?record_id=12903. The study was led by John T. Best and Joseph B. Reagan, Co-Chairs, and staffed by John Wendt, Study Director, Arul P. Mozhi, Senior Program Officer, Liza R. Hamilton, Administrative Coordinator, and Eva Labre, Program Associate. This study was led by the Laboratory Assessment Board in conjunction with the Space Studies Board and the Aeronautics and Space Engineering Board.

The National Research Council (NRC) selected and tasked the Committee on the Assessment of NASA Laboratory Capabilities to assess the status of the laboratory capabilities of the National Aeronautics and Space Administration (NASA) and to determine whether they are equipped and maintained to support NASA's fundamental research activities. Over the past 5 years or more, there has been a steady and significant decrease in NASA's laboratory capabilities, including equipment, maintenance, and facility upgrades. This adversely affects the support of NASA's scientists, who rely on these capabilities, as well as NASA's ability to make the basic scientific and technical contributions that others depend on for programs of national importance. The fundamental research community at NASA has been severely impacted by the budget reductions that are responsible for this decrease in laboratory capabilities, and as a result NASA's ability to support even NASA's future goals is in serious jeopardy. This conclusion is based on the committee's extensive reviews conducted at fundamental research laboratories at six NASA centers (Ames Research Center, Glenn Research Center, Goddard Space Flight Center, the Jet Propulsion Laboratory, Langley Research Center, and Marshall Space Flight Center), discussions with a few hundred scientists and engineers, both during the reviews and in private sessions, and in-depth meetings with senior technology managers at each of the NASA centers.

Several changes since the mid-1990s have had a significant adverse impact on NASA's funding for laboratory equipment and support services:

- Control of the research and technology "seed corn" investment was moved from an associate administrator focused on strategic technology investment and independent of important flight development programs' short-term needs, to an associate administrator responsible for executing such flight programs. The predictable result was a substantial reduction over time in the level of fundamental—lower technology readiness level, TRL—research budgets, which laboratories depend on to maintain and enhance their capabilities, including the procurement of equipment and support services. The result was a greater emphasis on higher TRL investments, which would reduce project risk.
- A reduction in funding of 48 percent for the aeronautics programs over the period fiscal year (FY) 2005-FY 2009 has significantly challenged NASA's ability to achieve its mission to advance U.S. technological leadership in aeronautics in partnership with industry, academia, and other government agencies that conduct aeronautics-related research and to keep U.S. aeronautics in the lead internationally.
- Institutional responsibility for maintaining the health of the research centers was changed from the associate administrator responsible for also managing the technology investment to the single associate administrator to whom all the center directors now report.
- NASA changed from a budgeting and accounting system in which all civil service manpower was covered in a single congressional appropriation to one in which all costs, including manpower, had to be budgeted and accounted for against a particular program or overhead account.

NASA personnel at the centers reported that reductions in budgets supporting fundamental research have had several consequences:

- Equipment and support have become inadequate.
- Centers are unable to provide adequate and stable funding and manpower for the fundamental science and technology advancements needed to support long-term objectives.
- Research has been deferred.
- Researchers are expending inordinate amounts of time writing proposals seeking funding to maintain their laboratory capabilities.
- Efforts are diverted as researchers seek funding from outside NASA for work that may not be completely consistent with NASA's goals.

The institutional capabilities of the NASA centers, including their laboratories, have always been critical to the successful execution of NASA's flight projects. These capabilities have taken years to develop and depend very strongly on highly competent and experienced personnel and the infrastructure that supports their research. Such capabilities can be destroyed in a short time if not supported with adequate resources and the ability to hire new people to learn from those who built and nurtured the laboratories. Capabilities, once destroyed, cannot be reconstituted rapidly at will. Laboratory capabilities essential to the formulation and execution of NASA's future missions must be properly resourced.

In the Strategic Plan for the Years 2007-2016, NASA states that it cannot accomplish its mission and vision without a healthy and stable research program. The fundamental research community at NASA is not provided with healthy or stable funding for laboratory capabilities, and therefore NASA's vision and missions for the future are in jeopardy. The innovation and technologies required to advance aeronautics, explore the outer planets, search for intelligent life, and understand the beginnings of the universe have been se-

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verely restricted by a short-term perspective and funding. The changes in the management of fundamental research represent a structural impediment to resolving this problem. Despite all these challenges, the NASA researchers encountered by the committee remain dedicated to their work and focused on NASA's future.

Approximately 20 percent of all NASA facilities are dedicated to research and development: on average, they are not state of the art: they are merely adequate to meet current needs. Nor are they attractive to prospective hires when compared with other national and international laboratory facilities. Over 80 percent of NASA facilities are more than 40 years old and need significant maintenance and upgrades to preserve the safety and continuity of operations for critical missions. A notable exception to this assessment is the new science building commissioned at GSFC. NASA categorizes the overall condition of its facilities, including the research centers, as "fairly good," but deferred maintenance (DM) over the past 5 years has grown substantially. Every year, NASA is spending about 1.5 percent of the current replacement value (CRV) of its active facilities on maintenance, repairs, and upgrades, but the accepted industry guideline is between 2 percent and 4 percent of CRV. Deferred maintenance grew from $1.77 billion to $2.46 billion from 2004 to 2009, presenting a staggering repair and maintenance bill for the future. The facilities that house fundamental research activities at NASA are typically old and require more maintenance than current funding will permit. As a result, they are crowded and often lack the modern layouts and utilities that improve operational efficiency.

The equipment and facilities of NASA's fundamental research laboratories are inferior to those witnessed by committee members at comparable laboratories at the U.S. Department of Energy (DOE), at top-tier U.S. universities, and at many corporate research institutions and are comparable to laboratories at the Department of Defense (DOD). If its basic research facilities were equipped to make them state of the art, NASA would be in a better position to maintain U.S. leadership in the space, Earth, and aeronautical sciences and to attract the scientists and engineers needed for the future.

The committee believes that NASA could reverse the decline in laboratory capabilities cited above by restoring the balance between funding for long-term fundamental research and technology development and short-term, mission-focused applications. The situation could be significantly improved if fundamental long-term research and advanced technology development at NASA were managed and nurtured separately from short-term mission programs. Moreover, in the light of recent significant changes in direction, NASA might wish to consider re-evaluating its strategic plan and developing a tactical implementation plan that will create, manage, and financially support the needed research capabilities and associated laboratories, equipment, and facilities. NASA is increasingly relying on a contractor-provided technician workforce to support those needs. If this practice continues, and if a strategy to ensure the continuity and retention of technical knowledge as the agency increasingly relies on a contractor-provided technician workforce is not currently in place, then such a strategy should be considered. Researchers in the smaller laboratories are forced to buy necessary laboratory equipment from their modest research grants, and it is not unusual for researchers in the larger laboratories to operate them at reduced throughput or not at all because the sophisticated and expensive research equipment for maintaining state-of-the-art capabilities is not being procured in sufficient quantities. Mechanisms need to be found that will provide the equipment and support services required to conduct the high-quality fundamental research befitting the nation's top aeronautics and space institution.

The specific findings and recommendations of this report are as follows:

Finding 1. On average, the committee classifies the facilities and equipment observed in the NASA laboratories as marginally adequate, with some clearly being totally inadequate and others being very adequate. The trend in quality appears to have been downward in recent years. NASA is not providing sufficient laboratory equipment and support services to address immediate or long-term research needs and is increasingly relying on the contract technician workforce to support the laboratories and facilities. Researchers in the smaller laboratories are forced to buy needed laboratory equipment from their modest research grants, while it is not unusual for researchers in the larger laboratories/facilities to operate facilities at reduced capabilities or not at all due to lack of needed repair resources. The sophisticated and expensive research equipment needed to achieve and maintain state-of-the-art capabilities is not being procured.

Recommendation 1A. Sufficient equipment and support services needed to conduct high-quality fundamental research should be provided to NASA's research community.

Recommendation 1B. If a strategy is not currently in place to ensure the continuity and retention of technical knowledge as the agency increasingly relies on a contractor-provided technician workforce, then such a strategy should be considered.

Finding 2. The facilities that house fundamental research activities at NASA are typically old and require more maintenance than funding permits. As a result, research laboratories are crowded and often lack the modern layouts and utilities that improve operational efficiency. The lack of timely maintenance can lead to safety issues, particularly with large, high-powered equipment. A notable exception is the new science building commissioned at Goddard Space Flight Center in 2009.

Recommendation 2A. NASA should find a solution to its deferred maintenance issues before catastrophic failures occur that will seriously impact missions and research operations.

Recommendation 2B. To optimize limited maintenance resources, NASA should implement predictive-equipment-failure processes, often known as health monitoring, currently used by many organizations.

Finding 3. Over the past 5 years or more, the funding of fundamental research at NASA, including the funding of facilities and equipment, has declined dramatically, such that unless corrective action is taken soon, the fundamental research community at NASA will be unable to support the agency's long-term goals. For example, if funding continues to decline, NASA may not be able to claim aeronautics technology leadership from an international and in some areas even a national perspective.

Recommendation 3A. To restore the health of the fundamental research laboratories, including their equipment, facilities, and

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support services, NASA should restore a better funding and leadership balance between long-term fundamental research/technology development and short-term mission-focused applications.

Recommendation 3B. NASA must increase resources to its aeronautics laboratories and facilities to attract and retain the best and brightest researchers and to remain at least on a par with international aeronautical research organizations in Europe and Asia.

Finding 4. Based on the experience and expertise of its members, the committee believes that the equipment and facilities at NASA's basic research laboratories are inferior to those at comparable DOE laboratories, top-tier U.S. universities, and corporate research laboratories and are about the same as those at basic research laboratories of DOD.

Recommendation 4. NASA should improve the quality and equipping of its basic research facilities, to make them at least as good as those at top-tier universities, corporate laboratories, and other better-equipped government laboratories in order to maintain U.S. leadership in the space, Earth, and aeronautic sciences and to attract the scientists and engineers needed for the future.

Controlling Cost Growth of NASA Earth and Space Science Missions

This report by the Committee on Cost Growth in NASA Earth And Space Science Missions is available at http://www.nap.edu/catalog.php?record_id=12946. The study was led by Ronald M. Sega, Chair, and staffed by Alan Angleman, Study Director, Andrea Rebholz, Program Associate, Linda Walker, Senior Program Assistant, and Catherine A. Gruber, Editor.

Study Background

Cost growth in Earth and space science missions conducted by the Science Mission Directorate (SMD) of the National Aeronautics and Space Administration (NASA) is a longstanding problem with a wide variety of interrelated causes. To address this concern, the NASA Authorization Act of 2008 (P.L. 110-422) directed the NASA administrator to sponsor an "independent external assessment to identify the primary causes of cost growth in the large-, medium-, and small-sized Earth and space science spacecraft mission classes, and make recommendations as to what changes, if any, should be made to contain costs and ensure frequent mission opportunities in NASA's science spacecraft mission programs." NASA subsequently requested that the National Research Council (NRC) conduct a study to:

- Review the body of existing studies related to NASA space and Earth science missions and identify their key causes of cost growth and strategies for mitigating cost growth;
- Assess whether those key causes remain applicable in the current environment and identify any new major causes; and
- Evaluate effectiveness of current and planned NASA cost growth mitigation strategies and, as appropriate, recommend new strategies to ensure frequent mission opportunities.

As part of this effort, NASA also asked the NRC to "note what differences, if any, exist with regard to Earth science compared with space science missions."

Cost Growth—Magnitude and Causes

NASA identified 10 cost studies and related analyses that this study uses as its primary references (listed in the References chapter and in Table 1.1). The committee generally concurs with the consensus viewpoints expressed in these studies as a whole, but in some areas, the studies reached different conclusions. For example, the prior studies calculated values for average cost growth ranging from 23 percent to 77 percent. Different studies reach different conclusions, because they examine different sets of missions and calculate cost growth based on different criteria. By definition cost growth is a *relative measure* reflecting comparison of an initial estimate of mission costs against costs actually incurred at a later time. But studies use initial estimates made at different points in mission life cycles (see Figure S.1), as well as cost estimates that cover different phases of mission life cycles. For example, some studies consider only development costs (up to but not including launch), but other studies consider all costs through the end of each mission.

In general, the earlier the initial estimate, the more the cost will grow. In addition, including a larger share of the later phases of a mission (such as launch, operations, and analysis of data collected by a mission) increases the total cost assigned to each mission and the absolute value of the cost growth (in dollars). These differences make it very difficult to derive a single, reliable value for the average cost growth of NASA Earth and space science missions on the basis of previous studies.

The primary references also indicate that most cost growth occurs after critical design review. This implies that the required level of cost reserves remains substantial, even late in the development process. In addition, a relatively small number of missions cause most of the total cost growth. For one large set of 40 missions, 92 percent of the total cost growth (in dollars) was caused by only 14 missions (one-third of the total number). Conversely, the 26 missions with the least cost growth (two-thirds of the total number) accounted for only 8 percent of the total cost growth (see Figure S.2).

The primary references identify a wide range of factors that contribute to cost and schedule growth of NASA Earth and space science missions. The most commonly identified factors are the following:

- Overly optimistic and unrealistic initial cost estimates,
- Project instability and funding issues,
- Problems with development of instruments and other spacecraft technology, and
- Launch service issues.

Additional factors identified in the primary references include schedule growth that leads to cost growth. Schedule growth and cost growth are well correlated because any problem that causes schedule growth contributes to and magnifies total mission cost growth. Fur-

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thermore, cost growth in one mission may induce organizational replanning that delays other missions in earlier stages of implementation, further amplifying overall cost growth. Effective implementation of a comprehensive, integrated cost containment strategy, as recommended herein, is the best way to address this problem.

Comprehensive, Integrated Strategy for Cost and Schedule Control

NASA sets the strategic direction of its Earth and space science programs using decadal surveys, the SMD science plan, and supporting roadmaps. A comprehensive, integrated approach to cost and schedule growth is also essential.

The primary references identify dozens of specific causes, make dozens of specific recommendations, and include additional dozens of findings concerning cost growth. The primary references, as a whole, are generally consistent and comprehensive, and so the individual causes of cost growth and the necessary corrective actions are not a mystery. However, rather than simply picking and choosing from among the many suggested causes, findings, and recommendations, development of a comprehensive, integrated strategy offers the best chance that future actions will work in concert to minimize or eliminate cost and schedule growth. An effective strategy would substantially reduce cost growth (beyond reserves) on individual missions and programs so that whatever growth does occur is offset by other missions and programs completed for less than the budgeted amount. This approach would allow NASA to execute the Earth and space science mission portfolio for the appropriated budget. Achieving this goal will require NASA to address both internal and external factors.

Internally, a comprehensive, integrated cost containment strategy would improve the definition of baseline costs and enhance the utility of NASA's independent cost-estimating capabilities. Early development of technologies and more effective program reviews would improve the ability to identify and effectively manage risks and uncertainties. Externally, NASA has the opportunity to collaborate with other federal agencies, the Office of Management and Budget, and Congress to sustain and improve critical capabilities and expertise in the industrial base and the nation's science and engineering workforce; to address cost and schedule risk associated with launch vehicles; and to improve funding stability.

Successful implementation of a comprehensive, integrated strategy to control cost and schedule growth of NASA Earth and space science missions would benefit both NASA and the nation, while enabling NASA to more efficiently and effectively carry out these critical missions.

Finding. ***Comprehensive, Integrated Cost Containment Strategy.*** Recent changes by NASA in the development and management of Earth and space science missions are promising. These changes include budgeting programs to the 70 percent confidence level and specifying that decadal surveys include independent cost estimates. However it is too early to assess the effectiveness of these actions, and NASA has not taken the important step of developing a comprehensive, integrated strategy.

Recommendation. ***Comprehensive, Integrated Cost Containment Strategy.*** NASA should develop a comprehensive, integrated strategy to contain cost and schedule growth and enable greater science opportunities. This strategy should include recent changes that NASA has already implemented as well as other actions recommended in this report.

Key Problems

In addition to developing a comprehensive, integrated cost containment strategy, and as detailed below, NASA should address specific issues related to cost realism and the development process for Earth and space science missions.

Cost Realism

Cost Estimates

NASA project staff generally estimate mission costs using detailed engineering analyses of labor and material requirements, vendor quotes, subcontractor bids, and the like. Non-advocate independent cost estimates in NASA are generally parametric cost estimates using statistical cost-estimating relationships based on historical relationships among cost and technical and programmatic variables (mass, power, complexity, and so on). In both cases, mission cost estimates are created by summing costs at lower levels of a project's work breakdown structure to obtain total project costs. Parametric cost models rely on observations rather than opinion, are an excellent tool for answering "what-if" questions quickly, and provide statistically sound information about the confidence level of cost estimates. In contrast, the process used within NASA to generate cost estimates on the basis of detailed engineering assessments does not provide a statistical confidence level and, in retrospect, has generally been less accurate than parametric cost models in estimating the cost of NASA Earth and space science missions.

A project manager or principal investigator who is personally determined to control costs can be of great assistance in avoiding cost growth. People and organizations tend to optimize their behavior based on the environment in which they operate. Unfortunately, instead of motivating and rewarding vigilance in accurately predicting and controlling costs, the current system incentivizes overly optimistic expectations regarding cost and schedule. For example, competitive pressures encourage (overly) optimistic assessments of the cost and schedule impacts of addressing uncertainties and overcoming potential problems. As a result, initial cost estimates generally are quite optimistic, underestimating final costs by a sizable amount, and that optimism sometimes persists well into the development process.

Recommendation. ***Independent Cost Estimates.*** NASA should strengthen the role of its independent cost estimating function by

- Expanding and improving NASA's ability to conduct parametric cost estimates, and
- Obtaining independent parametric cost estimates at critical design review (in addition to system requirements review and preliminary design review), comparing them to other estimates available from the project, and reconciling significant differences.

Cost Growth Methodology

The measurement of cost growth has been inconsistent across

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view, occur only when specified success criteria are likely to be met.

Launch Vehicles

Problems with the procurement of launch vehicles and launch services are a significant source of cost growth. Specific factors include increases in the cost of expendable launch vehicles, vendor issues such as strikes, weather-related issues at the launch site, problems with launch-site-facility capabilities, and delays in the availability of a given launch vehicle. In addition, if a mission is required to change launch vehicles, the costs can be substantial.

Recommendation. ***Launch Vehicles.*** Prior to preliminary design review, NASA should minimize mission-unique launch site processing requirements. NASA should also select the launch vehicle with appropriate margins as early as possible and minimize changes in launch vehicles.

Differences Between Earth and Space Science Missions

Different classes of missions face different challenges. Earth science missions typically have more complex, more costly, and more massive instruments than space science missions, because Earth science missions also have more stringent requirements in terms of pointing accuracy, resolution, stability, and so on, although astrophysics missions also have stringent pointing requirements, and planetary spacecraft and instrument technology must be able to survive long cruise phases and radiation environments that are sometimes quite extreme. Space science missions that leave Earth orbit have greater incentives to minimize spacecraft mass and power, and the average cost and average spacecraft mass of these missions are lower than those for Earth science missions. However, the size of the cost growth of Earth and space science missions has been comparable. Both Earth and space science missions have shown good correlation between (1) instrument schedule growth and instrument cost growth, (2) instrument cost/schedule growth and mission cost/schedule growth, and (3) the absolute costs of instruments and instrument complexity.

Life and Physical Sciences Research for a New Era of Space Exploration: An Interim Report

This report by the Committee for the Decadal Survey on Biological and Physical Sciences in Space is available at http://www.nap.edu/catalog.php?record_id=12944. The study's steering committee was led by Elizabeth R. Cantwell and Wendy M. Kohrt, Co-Chairs, and staffed by Sandra Graham, Study Director, Danielle Johnson-Bland, Senior Program Assistant, Lewis Groswald, Research Associate, and Catherine A. Gruber, Editor

In early 2009 the National Research Council's Committee for the Decadal Survey on Biological and Physical Sciences in Space began work on a study to establish priorities and recommendations for life and physical sciences research in microgravity and partial gravity for the decade 2010-2020. This effort represents the first decadal survey conducted for these fields. The committee is being assisted in this work by seven appointed panels, each focused on a broad area of life and physical sciences research. The study is considering research in two general categories: (1) research *enabled by* unique aspects of the space environment as a tool to advance fundamental and applied scientific knowledge and (2) research that *enables* the advances in basic and applied knowledge needed to expand exploration capabilities. The project's statement of task calls for delivery of two reports—an interim report and a final survey report.

Purpose of this Interim Report

During the period of the decadal survey's development, NASA received guidance in the fiscal year 2011 presidential budget request that directed it to extend the lifetime of the International Space Station (ISS) to 2020. This step considerably altered both the research capacity and the role of the ISS in any future program of life and physical sciences microgravity research. In addition, the budget initiated other potential changes that might affect both the organization and the scale of these programs at NASA. The purpose of this interim report is to provide timely input to the ongoing reorganization of programs related to life and physical sciences microgravity research, as well as to near-term planning or replanning of ISS research. Although the development of specific recommendations is deferred until the final report, this interim report does attempt to identify programmatic needs and issues to guide near-term decisions that the committee has concluded are critical to strengthening the organization and management of life and physical sciences research at NASA. This report also identifies a number of broad topics that represent near-term opportunities for ISS research. Topics discussed briefly in this interim report reflect the committee's preliminary examination of a subset of the issues and topics that will be covered in greater depth in the final decadal survey report.

Programmatic Issues for Strengthening the Research Enterprise

As the result of major reorganizations and shifting priorities within the past decade at NASA, there is currently no clear institutional home within the agency for the various scientific endeavors that are focused on understanding how biological and physical systems behave in low-gravity environments. As NASA moves to rebuild or restructure programs focused on these activities, it will have to consider what elements to include in that program.

In its preliminary analysis, the committee has identified a number of critical needs for a successful renewed research endeavor in life and physical sciences. These include:

- Elevating the priority of research in the agenda for space exploration;
- Selecting research likely to provide value to an optimal range of future mission designs;
- Developing a comprehensive database that is accessible to the scientific community;

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programs, NASA centers, and Congress. The Government Accountability Office and Congress generally consider the baseline to be the first time a mission appears as a budget line item in an appropriations bill, which is often before preliminary design review. The contents of NASA estimates also differ—some estimates include Phase A and B, some start with Phase C, some (but not all) include launch costs and/or mission operations, and some include NASA oversight and internal project management costs. These differences make it difficult to develop a clear understanding of trends in cost and schedule growth.

Recommendation. *Measurement of Cost Growth.* NASA, Congress, and the Office of Management and Budget should consistently use the same method to quantify and report cost. In particular, they should use as the baseline a life cycle cost estimate (that goes through the completion of prime mission operations) produced at preliminary design review.

Development Process

Management of Announcement of Opportunity Missions and Directed Missions

NASA implements two separate and distinct classes of Earth and space science missions—announcement of opportunity (AO) missions and directed missions. NASA headquarters competitively selects AO missions from proposals submitted in response to periodic AOs by teams led by a principal investigator (PI), who is commonly affiliated with a university, but may work in industry or for NASA. NASA headquarters determines the scientific goals and requirements for directed missions, which are sometimes referred to as facility class missions or flagship missions. Headquarters then directs a particular NASA center, usually Goddard Space Flight Center or the Jet Propulsion Laboratory, to implement the mission.

The differing nature and goals of directed and AO missions call for different management approaches. AO missions are on average much smaller than directed missions, and the impact of cost growth in AO missions, which are managed within a mission budget line (e.g., Discovery), is limited to other missions within the line. Flagship missions, however, are typically much larger than AO missions, and so cost growth in these missions has a much greater potential to diminish NASA's Earth and space science enterprise as a whole.

Recommendation. *Management of Large, Directed Missions.* NASA headquarters' project oversight function should pay particular attention to the cost and schedule of its larger missions (total cost on the order of $500 million or more), especially directed missions (which form a single line item).

Recommendation. *Management of Announcement of Opportunity (AO) Missions.* NASA should continue to emphasize science in the AO mission selection process, while revising the AO mission selection process to allocate a larger percentage of project funds for risk reduction and improved cost estimation prior to final selection.

Recommendation. *Incentives.* NASA should ensure that proposal selection and project management processes include incentives for program managers, project managers, and principal investigators to establish realistic cost estimates and minimize or avoid cost growth at every phase of the mission life cycle, for both directed missions and announcement of opportunity missions.

Technology and Instrument Development

NASA Procedural Requirements (NPR) 7120.5, NASA Space Flight Program and Project Management Requirements, require that "during formulation, the project establishes performance metrics, explores the full range of implementation options, defines an affordable project concept to meet requirements specified in the Program Plan, develops needed technologies, and develops and documents the project plan" (NASA, 2007, Section 2.3.4). However, despite these requirements, the primary references identify an ongoing need to improve technical and programmatic definition at the beginning of a project. The limited time and resources typically available in phases A and B to mature new technology and solidify system design parameters contribute to cost growth through higher risk and unrealistic cost estimates.

Instrument technology is particularly important because Earth and space science missions generally require special-purpose, one-of-a-kind components. Delays and cost increases for instrument development are pervasive and impact a large number of missions. This problem is exacerbated by shrinkage of the U.S. industrial base that supports space system development.

Recommendation. *Technology Development.* NASA should increase the emphasis in phases A and B on technology development, risk reduction, and realism of cost estimates.

Recommendation. *Instrument Development.* NASA should initiate instrument development well in advance of starting other project elements and establish a robust instrument technology development effort relevant to all classes of Earth and space science missions to strengthen and sustain the nation's instrument development capability.

Recommendation. *Decadal Surveys.* NASA should ensure that guidance regarding the development of instruments and other technologies is included in decadal surveys and other strategic planning efforts. In particular, future decadal surveys should prioritize science mission areas that could be addressed by future announcements of opportunity and the instruments needed to carry out those missions.

Major Reviews

NASA has increased the size and number of external project reviews to the point that some reviews are counterproductive and disruptive, especially for small missions. Large numbers of reviews diffuse responsibility and accountability, creating an environment where NASA senior managers can become dependent on review teams with many outside members who sometimes do not understand NASA, the field center in question, and/or the mission being reviewed. In addition, major reviews are sometimes conducted as scheduled even though a project may not have progressed as rapidly as expected and, as a result, cannot achieve the intended review criteria, programmatically and/or technologically.

Recommendation. *External Project Reviews.* NASA should reassess its approach to external project reviews to ensure that (1) the value added by each review outweighs the cost (in time and resources) that it places on projects, (2) the number and the size of reviews are appropriate given the size of the project, and (3) major reviews, such as preliminary design review and critical design re-

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- Implementing a translational science component to ensure bidirectional interactions between basic science and the development of new mission options; and
- Encouraging, and then accommodating, team science approaches to what are inherently complex multidisciplinary challenges.

In addition, as noted repeatedly by the scientific community that has provided input to this study, reasonable stability and predictability of research funding are critical to ensuring productive and sustained progress toward research goals in any program.

In the context of an institutional home for an integrated research agenda, the committee noted that program leadership and execution are likely to be productive only if aggregated under a single management structure and housed in a NASA directorate or other key organization that understands the value of science and has the vision to see its potential application in future exploration missions. Ultimately, any successful research program would need to be directed by a leader of significant gravitas who is in a position of authority within the agency and has the communication skills to ensure that the entire agency understands and concurs with the key objective to support and conduct high-fidelity, high-quality, high-value research.

International Space Station Research Opportunities

The International Space Station provides a unique platform for research, and past studies have noted the critical importance of its research capabilities to support the goal of long-term human exploration in space. Although it is difficult to predict the timing for the transition of important research questions from ground- to space-based investigations, the committee identifies in this interim report a number of broad topics that represent near-term opportunities for ISS research. These topics, which are not prioritized, fall under the following general areas:

- Plant and microbial research to increase fundamental knowledge of the gravitational response and potentially to advance goals for the development of bioregenerative life support;
- Behavioral research to mitigate the detrimental effects of the spaceflight environment on astronauts' functioning and health;
- Human and animal biology research to increase basic understanding of the effects of spaceflight on biological systems and to develop critically needed countermeasures to mitigate the negative biological effects of spaceflight on astronauts' health, safety, and performance;
- Physical sciences research to explore fundamental laws of the universe and basic physical phenomena in the absence of the confounding effects of gravity; and
- Translational and applied research in physical sciences that can provide a foundation of knowledge for the development of systems and technologies enabling human and robotic exploration.

This report contains discussion of various topics within each of these areas. The committee notes, however, that although the ISS is a key component of research infrastructure that will need to be utilized by a biological and physical research sciences program, it is only one component of a healthy program. Other platforms will play an important role and, in particular, research on the ISS will need to be supported by a parallel ground-based program to be scientifically credible.

STAFF NEWS

Graduations

Lewis Groswald, Research Associate and former Lloyd V. Berkner Space Policy Intern, graduated on May 16, 2010 from the Space Policy Institute of the Elliot School of International Affairs at George Washington University with an M.A. in international acience and technology policy. Congratulations Lewis!

Lloyd V. Berkner Space Policy Internship

The Lloyd V. Berkner Space Policy Internship Program selected Dara Fisher (University of Michigan) and Andreas Frick (Iowa State University) as participants in its 2010 summer program. The goal of the program is to provide promising students with the opportunity to work in the area of civil space-research policy in the nation's capital, under the aegis of the SSB. Additional information on the program can be found in this newsletter and at http://sites.nationalacademies.org/SSB/ssb_052239.

Dara Fisher is a rising senior at the University of Michigan studying Earth system science engineering with a concentration in space weather and a minor in international engineering. On campus, Ms. Fisher serves as the president of the University of Michigan engineering student government, is a member of the engineering academic and leadership honor societies, and has done research in the fields of laboratory astrophysics and remote sensing. She first became interested in space and space exploration in high school, but discovered her love of science policy after taking a class entitled "Beyond Sputnik: National Science Policy in the 21st Century" in the spring of her junior year. After she completes her undergraduate studies in spring 2011, Ms. Fisher plans to pursue a master's degree in science and technology policy.

Andreas Frick grew up in Germany and recently graduated from Iowa State University with a double major in aerospace engineering and political science. After getting involved with the Space Systems and Controls Lab at Iowa State, he developed a great interest in space exploration and space policy. During this time, he participated in a high-altitude ballooning program and led a design team for a Mars-analog rover to compete at the Mars Society's annual University Rover Challenge. Previously, he participated in a sounding rocket experiment of an inflatable Mars probe concept at the Esrange Space Center, Sweden, as part of an internship with the University of the German Armed Forces in Munich. Mr. Frick hopes to continue his education in space policy by combining technical with political aspects of space exploration and will be pursuing a master's degree in international science and technology policy at George Washington University.

COSPAR NEWS

The COSPAR Council elected new officers during its meeting in Bremen, Germany, on July 17. The terms of the new officers begin at the end of the COSPAR Scientific Assembly in Bremen. The council also selected Moscow, Russia, as the provisional host of the 2014 COSPAR Scientific Assembly.

President
Giovanni F. Bignami, (Italy)
Vice Presidents
Robert P. Lin (USA)
Ji Wu (China)
Bureau Members
Inez S. Batista (Brazil)
Karl-Heinz Glassmeier (Germany)
Achuthan Jayaraman (India)
Sho Sasaki (Japan)
Jean-Pierre St.-Maurice (Canada)
Lev Zelenyi (Russia)
Finance Committee Chair
Wim Hermsen (Netherlands)
Finance Committee Members
Iver Cairns (Australia)
Marcos E. Machado (Argentina)

COSPAR Awards and Medals 2010

COSPAR scientific awards and medals for 2010 have been announced and will be presented during the 38th COSPAR Scientific Assembly on July 19th, 2010 in Bremen, Germany. The recipients are listed below. Academy membership and relevant involvement in SSB activities is indicated where appropriate.

COSPAR Space Science Award
Günther Hasinger, MPI for Plasma Physics, Garching, Germany
Steven W. Squyres, Cornell University, Ithaca, NY
- Chair, Committee on Planetary Science Decadal Survey (2009-)
- Member, Task Group on Sample Return from Small Solar System Bodies (1997-1998)
- Member, Task Group on Research and Analysis Programs (1996-1998)

CONSPAR International Cooperation Medal
Lee-Lueng Fu, Jet Propulsion Laboratory, Pasadena, CA
- Member, NAE (elected 2008)

Yves Menard (posthumous), CNES, France

COSPAR William Nordberg Medal
Kuo-Nan Liou, University of California, Los Angeles, CA
- Member, NAE (elected 1999)

COSPAR Distinguished Service Medal
Margaret Ann Shea, Air Force Research Laboratory, Hanscom AFB, MA.
- Member, Committee on Solar and Space Physics (1996-1999)

Massey Award
Harvey Tananbaum, Smithsonian Astrophysical Observatory, Cambridge, MA
- Member, NAS (elected 2005)
- Member, Space Studies Board (2004-2007)
- Member, Committee on an Assessment of Balance in NASA's Science Programs (2006-2006)
- Member, Committee on the Scientific Context for Space Exploration (2004-2005)
- Member, Committee on Space Astronomy and Astrophysics (1981-1984)

Vikram Sarabhai Medal
Zuyin Pu, School of Earth and Space Sciences, Peking University, Beijing, China

Jeoujang Jaw Award
Calvin T. Swift, University of Massachusetts, Amherst, MA

Zeldovich Medals
Scientific Commission A—Space Studies of the Earth's Surface, Meteorology and Climate
Paul I. Palmer, University of Edinburgh, Scotland
Scientific Commission B—Space Studies of the Earth-Moon System, Planets, and Small Bodies of the Solar System
Anna A. Fedorova, Russian Academy of Sciences, Russia
Scientific Commission C—Space Studies of the Upper Atmospheres of the Earth and Planets Including Reference Atmospheres
Jiuhou Lei, University of Colorado, Boulder, CO
Scientific Commission D—Space Plasmas in the Solar System, Including Planetary Magnetosphers
Yasuhito Narita, Technical University of Braunschweig, Germany
Scientific Commission E—Research in Astrophysics from Space
Vito Sguera, Space Astrophysics and Cosmic Physics Institute, Bologna, Italy
Scientific Commission F—Life Sciences as Related to Space
Oleg A. Gusev, National Institute of Agrobiological Sciences, Tsukuba, Japan
Scientific Commission G—Materials Sciences in Space
Junichiro Shiomi, University of Tokyo, Japan
Scientific Commission H—Fundamental Physics in Space
John W. Conklin, Stanford University, Palo Alto, CA

LLOYD V. BERKNER SPACE POLICY INTERNSHIPS

WE ARE CURRENTLY ACCEPTING APPLICATIONS FOR INTERNSHIPS FOR THE SUMMER 2011 PROGRAM

The goal of the Lloyd V. Berkner Space Policy Internship program is to provide promising undergraduate and graduate students with the opportunity to work in the area of civil space research policy in the nation's capital, under the aegis of the SSB.

Established in 1958 to serve as the focus of the interests and responsibilities in space research for the National Academies, the Board provides an independent, authoritative forum for information and advice on all aspects of space science and applications, and it serves as the focal point within the National Academies for activities on space research. It oversees advisory studies and program assessments, facilitates international research coordination, and promotes communications on space science and science policy between the research community, the federal government, and the interested public. The SSB also serves as the U.S. National Committee for the International Council for Science Committee on Space Research (COSPAR).

The Lloyd V. Berkner Space Policy Internships, named after the first chair of the SSB, are offered twice annually. The summer program is restricted to undergraduates, and the autumn 2010 program is open to both undergraduate and graduate students.

The SSB is now accepting applications from undergraduates for its summer 2011 program. The deadline for applications is February 4, 2011. Successful candidates will be contacted no later than March 4, 2011.

Individuals seeking a Lloyd V. Berkner Space Policy Internship must have the following minimum qualifications:

- Be a registered student at a U.S. university or college;
- Have completed his/her junior year, majoring in physics, astronomy, chemistry, biology, or geology (other areas considered on a case-by-case basis);
- Have long-term career goals in space science research, applications, or policy;
- Possess good written and verbal communications skills and a good knowledge of his/her particular area of study;
- Be capable of responding to general guidance and working independently; and
- Be familiar with the internet, world wide web and basic research techniques (familiarity with Microsoft Word and HTML is highly desirable, but not essential).

NOTE: SELECTION OF INTERN AND INITIATION OF PROGRAM IS DEPENDENT ON AVAILABILITY OF FUNDS.

Visit http://sites.nationalacademies.org/SSB/ssb_052239 to learn more about the internship program and to get application information.

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*Staff of other NRC Boards who are shared with the SSB

National Research Council
Space Studies Board 2010 Workshop

Sharing the Adventure with the Public
The Value and Excitement of “Grand Questions” of Space Science and Exploration

November 8-10, 2010

Arnold and Mabel Beckman Center Auditorium
100 Academy Drive
Irvine, California

Over the past 50 years NASA has advanced our knowledge of Earth, the solar system, and the universe; expanded human presence in space; and searched for evidence of life elsewhere. These accomplishments arguably have been motivated by five “Grand Questions”:

1. **How did the universe begin and how is it evolving?**
2. **Are we alone?**
3. **How did the solar system begin and how is it evolving?**
4. **Will the Earth remain a hospitable home for humanity in the future?**
5. **What could the future hold for humans in space?**

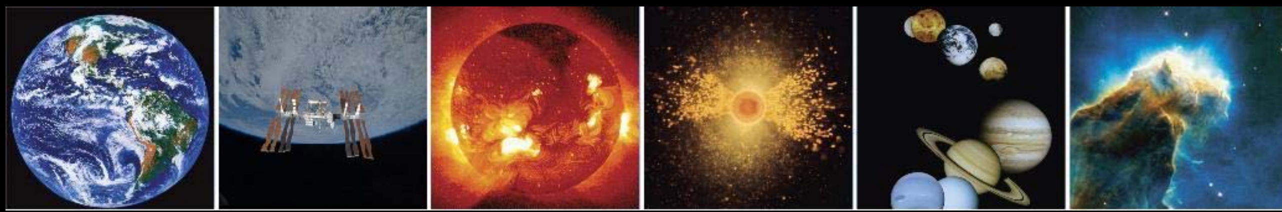
NASA will continue to address these questions in the coming decades, largely through science and exploration missions. While doing so, a key goal will remain of successfully conveying to the public an understanding of and an appreciation for this quest for knowledge.

The Space Studies Board’s 2010 Workshop will explore both how these grand questions focus on the nation's space research program and how best to convey the value and excitement to the public. The workshop will bring together leading scientists and experts from the communications and social marketing sectors to share lessons learned and best practices. A summary of the workshop discussions will be released by the NRC.

For further information and to register for the workshop go to:

http://www.nas.edu/ssb

look under “News & Events”



SSB CALENDAR

JULY

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July 7-8	*Committee on Earth Studies (CES)*—**Washington, DC**
July 13-15	*Planetary Science Decadal Survey Steering Committee*—**Washington, DC**
July 28-30	*Decadal Survey on Biological and Physical Sciences in Space Steering Committee*—**Woods Hole, MA**
August 3-4	*Planetary Science Decadal Survey Steering Committee*—**Washington, DC**
August 23-25	*Space Studies Board Executive Committee*—**Woods Hole, MA**
September 1-3	*Solar and Space Physics (Heliophysics) Decadal Survey Steering Committee*—**Washington, DC**
October 13-15	*Committee on Origins and Evolution of Life (COEL)*—**Woods Hole, MA**

WWW.NATIONALACADEMIES.ORG/SSB/

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For a complete list of titles visit our website at <http://sites.nationalacademies.org/SSB/ssb_051650>

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(Search for available titles then click the blue "Sign in" button to download a free PDF version of the report.)

Hardcopy versions of all reports are available free of charge from the SSB while supplies last.
To request a hardcopy of a report please send an email to ssb@nas.edu, include your name, mailing address, and affiliation.
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- ☐ Revitalizing NASA's Suborbital Program: Advancing Science, Driving Innovation, and Developing a Workforce (2010)
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- ☐ Near-Earth Objects Surveys and Hazard Mitigation Strategies: Interim Report (2009)
- ☐ America's Future in Space: Aligning the Civil Space Program with National Needs (2009)
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- ☐ Radioisotope Power Systems: An Imperative for Maintaining U.S. Leadership in Space Exploration (2009) CD Only
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- ☐ Space Science and the International Traffic in Arms Regulations: Summary of a Workshop (2008)
- ☐ Assessment of the NASA Astrobiology Institute (2008)
- ☐ Grading NASA's Solar System Exploration Program: A Midterm Review (2008)
- ☐ NASA's Beyond Einstein Program: An Architecture for Implementation (2007)
- ☐ The Limits of Organic Life in Planetary Systems (2007)

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