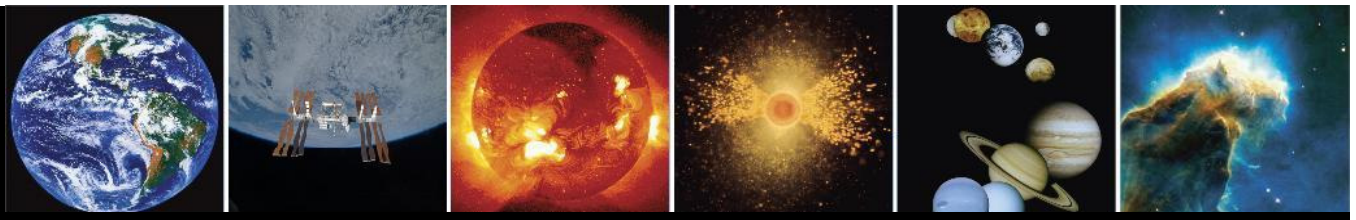
SPACE STUDIES BOARD NEWS



JULY—SEPTEMBER 2012

INSIDE THIS ISSUE

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Charles F. Kennel, Chair, SSB

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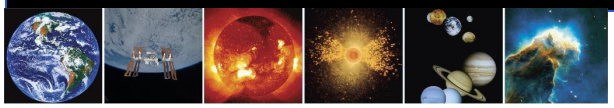

FROM THE CHAIR

In lieu of his quarterly column, the U.S. Senate hearing testimony of SSB Chair Charlie Kennel is reprinted below. Other witnesses were Dr. Steven W. Squyres Goldwin Smith Professor of Astronomy Cornell University; and Mr. Jim Maser President Pratt & Whitney Rocketdyne. Archived webcast and statements are available at <http://commerce.senate.gov/public/index.cfm?p=Hearings>.

Leadership in Space

Statement of Charles F. Kennel, Ph.D.
Professor of Atmospheric Science and
Director Emeritus, Scripps Institution of Oceanography
University of California San Diego
and Chair, NRC's Space Studies Board
Division on Engineering and Physical Sciences
National Research Council, The National Academies
before the
U.S. Senate Committee on Commerce,
Science, and Transportation Hearing
The Path from LEO to Mars
September 12, 2012

Mr. Chairman, Ranking Member Hutchinson, members of the committee:

I am Charlie Kennel, Chair of the National Research Council's Space Studies Board and a Distinguished Professor of Atmospheric Science and Director Emeritus in the Scripps Institution of Oceanography at the University of California, San Diego (UCSD). The National Research Council (NRC) is the operating arm of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine of the National Academies, chartered by Congress in 1863 to advise the government on matters of science and technology. The Space Studies Board (SSB) was established in 1958 to serve as the focus of the NRC's interests and responsibilities in space science research.

The focus of this hearing is progress in implementing the goals of the 2010 NASA Authorization Act—legislation that is clearly aimed at maintaining U.S. leadership in our exploration of space.

Two recent events remind us how important leadership is. Several weeks ago, America lost the first astronaut ever to land on another world, Neil Armstrong. Neil was respected throughout the space community, not only for his competence and his courage, but also for his modesty. He never failed to say that his success was the Nation's success. He credited it to the creativity of tens of thousands of scientists and engineers in NASA, academia, and industry and to the support of millions of the American people. He saw how an inspiring goal gets a supreme effort from the tens of thousands, and enduring support from the millions.

A little more than a month ago, *Curiosity* landed on Mars, and millions of people around the world shared its "seven minutes of terror" with the thousands who built it. This too was leadership, even though there was no astronaut on board. We are confident that *Curiosity* will carry out state-of-the-art science motivated by a very clear goal—to search for evidence of organic molecules and water, the prerequisites for life. But really, it was the audacity of the landing—the incredible sequence of things never done before that had to come out right—that marked *Curiosity* for leadership. One more time, NASA showed that when it is given something extraordinarily difficult to do, it beats the odds.

Where are NASA's next opportunities for leadership? This is a question that the Space Studies Board and our sister committee the Aeronautics and Space Engineering Board are established to help answer for the nation. Identifying the opportunities for advancing our knowledge of space through human and robotic exploration is the motivation behind the NRC's studies that the SSB and ASEB oversee.

For nearly 3 years. I served as Associate Administrator of NASA for "Mission to Planet Earth," and 12 years on the NASA Advisory Council, including 4 years as its Chair. In 2009, I served on President Obama's Review of Human Space Flight Plans, the so-called "Augustine Commission", and since 2008 I have chaired the Space Studies Board. The views I will present today, which are my own personal perspectives, are largely informed by the work of the Augustine Commission and the Space Studies Board.

Human Spaceflight

As you know, the 2010 NASA Authorization Act asked the NRC to appoint a committee to undertake a study to review the long-term goals, core capabilities, and direction of U.S. human spaceflight activities and to make recommendations to enable a sustainable U.S. human spaceflight program. Following the transfer of funds from NASA to the NRC, the study commenced on August 1, 2012, and the committee recruitment process is currently underway and making good progress. Prior to the start of the actual study, a number of activities were carried out under a separate initiation task. Those activities included outreach, collection of research materials, the identification of skillsets, knowledge and perspectives critical to the study, and the broad solicitation of names as well as the review of qualifications for an extensive set of committee candidates. Outreach activities conducted in this period included a discussion session held during the Global Space Exploration Conference in Washington, DC, in which representatives from several international space agencies discussed the perspectives of their citizens and governments on the value, rationale, and future direction of human space exploration.

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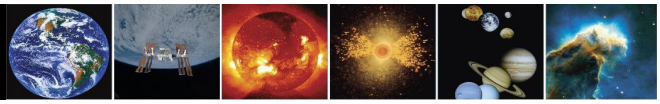


(Continued from page 2)

As recognized by the leadership of the NRC, this study embodies technical, sociological—and even philosophical—issues. The study encompasses both exceptional challenges and exceptional opportunities. Accordingly, the NRC staff who are preparing for this important activity have had an extensive series of wide-ranging discussions across the spectrum of disciplines represented in the National Academies family, as well as with the NASA community, the international community, and with members of the space community.

Once the committee holds its first meeting, tentatively scheduled for later this year, the committee will begin to solicit broadly based, but directed, public and stakeholder input to understand better the motivations, goals, and possible evolution of human spaceflight. The next task is to start to identify a set of high-priority enduring questions that describe the rationale for and value of human exploration in a national and international context. The committee has been charged to provide prioritized recommendations and decision rules that could enable and guide future planning for U.S. human space exploration. The recommendations will describe a high-level strategic approach to ensuring the sustainable pursuit of national goals enabled by human space exploration, answering enduring questions, and delivering value to the nation. Notwithstanding the considerable challenge this study represents, it is my firm belief that this committee will benefit enormously from the fact that they will have been given 22 months to complete their report, a time period that will allow them to consider carefully the difficult challenge they have been set.

In addition to the many technical studies that NASA and others have produced over the years, the study committee will also benefit from previous work by the NRC in related areas. The NRC study *America's Future in Space: Aligning the Civil Space Program with National Needs* outlines how changes in geopolitical context since the end of the Cold War are affecting the national space program and will be among the reports the new study will consider as it gets started. Our recent report *Recapturing a Future for Space Exploration: Life and Physical Sciences Research for a New Era* is a decadal survey recommending a research portfolio that would ensure that the Nation is ready for the next significant phase of human spaceflight. This report presents an examination of the science and technology that can bring about these achievements—such as a deeper understanding of the role of gravity in the regulation of biological systems, how to control critical fluid behavior in space exploration systems, and research on fire safety and water production in an extraterrestrial environment. The report has two foci: research that enables space exploration and research that is enabled by access to space. This is the scientific research needed to pave the way for the profoundly advanced capabilities we must have in order to make the most ambitious exploration goals not only feasible, but cost effective. The International Space Station (ISS) and its research facilities now provide an unparalleled window of opportunity to make significant and sustained progress on these questions, but this will require a full and vigorous exploitation of the Nation's enormous investment in the space station.

Virtually every NASA success has resulted from technological breakthroughs. Our NRC report *NASA Space Technology Roadmaps and Priorities: Restoring NASA's Technological Edge and Paving the Way for a New Era in Space* identifies the top 10 technical challenges as well as the highest-priority technologies for NASA missions that extend and sustain human activities beyond low Earth orbit, explore the evolution of the solar system and the potential for life elsewhere, and expand our understanding of Earth and the universe in which we live.

Some people have said that NASA relinquished leadership of the human spaceflight enterprise when it retired the space shuttle. In my personal opinion, nothing could be further from the truth. The International Space Station, if nothing else, guarantees U.S. leadership for the rest of the decade, and there are at least three things NASA can do now to ensure leadership after that. The first is to realize the full promise of ISS utilization, building on the foundations of its status as a National Laboratory and by rebuilding the Nation's research program in life and microgravity science, as outlined in the decadal survey report mentioned earlier. Next is to encourage America's new entrepreneurial launch industry, not only to support human spaceflight and to bring down the cost to launch scientific spacecraft, but also to give a boost to an entirely new space economy. Finally, by the end of this decade, NASA has to make a firm start on a long-term program of human exploration beyond low Earth orbit. We should not

(Continued on page 17)

SSB MEMBERSHIP

Lessons Learned in Decadal Planning in Space Science

A Workshop

November 12-13, 2012

National Academies
Arnold and Mabel Beckman Center
Irvine, California

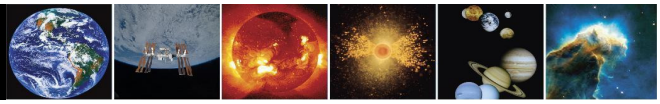
hosted by the Space Studies Board
in collaboration with the Board on Physics and Astronomy

This workshop will review and discuss key aspects of the most recent National Research Council decadal surveys in space science—solar and space physics (2012), planetary science (2011), astronomy and astrophysics (2010), and Earth science and applications from space (2007)—with the goal of identifying lessons learned and best practices.

The workshop will bring together a variety of stakeholders in the space community who are impacted by and/or are responsible for the formulation and implementation of the decadal surveys. In addition to focusing on the decadal surveys, the workshop will also afford an opportunity to discuss the recent mid-decade reviews. To accomplish its goals, the workshop will foster a dialog among the workshop attendees with a view to identifying ideas for the future evolution of the decadal survey and mid-decade review processes.

An NRC-appointed planning committee is working on the structure and content of the workshop.

More information on the workshop agenda and how to register is available on the workshop's web site, available at <http://sites.nationalacademies.org/SSB/CurrentProjects/SSB_070954>.



SSB ACTIVITIES

THE BOARD AND ITS STANDING COMMITTEES

The **Space Studies Board (SSB)** did not meet during this quarter, however, the Executive Committee of the Board (XCOM) met on August 8-9 at the Jet Propulsion Laboratory in Pasadena, CA, for its annual planning session. In addition to other strategic planning discussions, the XCOM met with former chairs and vice chairs of the SSB, current chairs of the SSB standing committees, staff from OSTP, the U.S. Senate, and NASA SMD for a discussion on the impact and roles of the SSB and future challenges for the space science community. The XCOM also received a briefing from Doug McCuistion (NASA) and Jim Green (NASA) on the status of the Curiosity/Mars Science Laboratory, which had just landed on August 5, 2012. The next full meeting of the Board will be held November 14 at the Arnold and Mabel Beckman Center in Irvine, CA, and will be preceded by a workshop on Lessons Learned in Decadal Planning in Space Science on November 12-13 (see below). Visit <http://www.nas.edu/ssb> to stay up to date on board, workshop, and study committee meetings and developments.

The SSB 2012 workshop **Lessons Learned in Decadal Planning in Space Science** on November 12-13 at in Irvine, CA, will focus on lessons learned and best practices from the most recent decadal surveys—solar and space physics, planetary science, astronomy and astrophysics, and Earth science and applications from space—and their respective mid-term assessments. The workshop agenda will foster a dialogue among stakeholders in the space community who are impacted by and/or are responsible for the formulation and implementation of the decadal surveys. To learn more—see page 4 of this newsletter and visit <http://sites.nationalacademies.org/SSB/CurrentProjects/SSB_070954>.

The **Committee on Astronomy and Astrophysics (CAA)** held a WebEx meeting on July 27 to hear a presentation on the final report of the WFIRST Science Definition Team. Neil Gehrels, NASA WFIRST Study Scientist, presented the report's findings. Paul Hertz, Director of the Astrophysics Division also spoke about what NASA is doing in response to the report. The committee held another WebEx meeting on September 7 to hear a presentation on the report of the Portfolio Review Committee. Daniel Eisenstein, chair of the committee, delivered the presentation. Jim Ulvestad, Director of the Astronomy Division at NSF, discussed how the NSF was going to move forward procedurally. The CAA will meet again in March 2013 during the SSB's Space Science Week and will hold several teleconference-based meetings in the interim. More information about CAA is available at <http://sites.nationalacademies.org/BPA/BPA_048755>.

The **Committee on Earth Science and Applications from Space (CESAS)** (formerly the Committee on Earth Studies) held its first meeting on July 10-11 at the Keck Center of the National Academies in Washington, DC (reported on in the last newsletter, available at <http://sites.nationalacademies.org/SSB/ssb_052298>). CESAS will meet in person again in March 2013 during the SSB Standing Committees' Space Science Week; in the interim, it will continue to hold e-meetings. For more information about CESAS and to learn about upcoming meetings, go to <http://sites.nationalacademies.org/SSB/SSB_066587>.

The **Committee on Astrobiology and Planetary Science (CAPS)**, a new activity combining the responsibilities formerly exercised by COMPLEX and COEL, held its second meeting at the National Academies' Beckman Center in Irvine, CA, on September 24-25. CAPS's primary responsibility is to monitor the implementation of the *Vision and Voyages* planetary science decadal survey. The September meeting was devoted primarily to briefings and discussions concerning the current status of NASA's Mars exploration plans for the post-2016 period and the most recent results from the Europa flagship mission rescoping activities. Among the other agenda topics were briefings on the initial results from the Mars Science Laboratory and planning for the European Space Agency's Jupiter Icy Moons Orbiter mission. The committee's first meeting of 2013 will be held at the National Academy of Sciences building in Washington, DC, on March 6-8 during the SSB's Space Science Week. More information about CAPS is available at <http://sites.nationalacademies.org/SSB/SSB_067577>.

The **Committee on Solar and Space Physics (CSSP)** is on hiatus until the completion of the solar and space physics (heliophysics) decadal survey. We anticipate restart of the committee in the fourth quarter of 2012. Co-chairs J. Todd Hoeksema, Stanford University, and Mary K. Hudson, Dartmouth College, have been appointed. More information about CSSP is available at <http://sites.nationalacademies.org/SSB/ssb_052324>.

More information on the SSB and ASEB Board Meetings is at http://sites.nationalacademies.org/SSB/SSB_054577 (SSB) and http://sites.nationalacademies.org/DEPS/ASEB/DEPS_058923 (ASEB)

SSB STANDING COMMITTEES

Committee on Astrobiology and Planetary Science (CAPS)

Philip R. Christensen, Arizona State University (Co-Chair)
J. Gregory Ferry, Pennsylvania State University (Co-Chair)

Committee on Astronomy and Astrophysics (CAA)
(joint with the Board on Physics and Astronomy)

Paul L. Schechter, MIT (Co-Chair)
David N. Spergel, Princeton University (Co-Chair)

Committee on Earth Science and Applications from Space (CESAS)

Mark R. Abbott, Oregon State University (Chair)
Joyce E. Penner, University of Michigan (Vice Chair)

Committee on Solar and Space Physics (CSSP)

J. Todd Hoeksema, Stanford University (Co-Chair)
Mary K. Hudson, Dartmouth College (Co-Chair)

For more information,
go to http://sites.nationalacademies.org/SSB/ssb_052296

SSB ACTIVITIES, CONTINUED

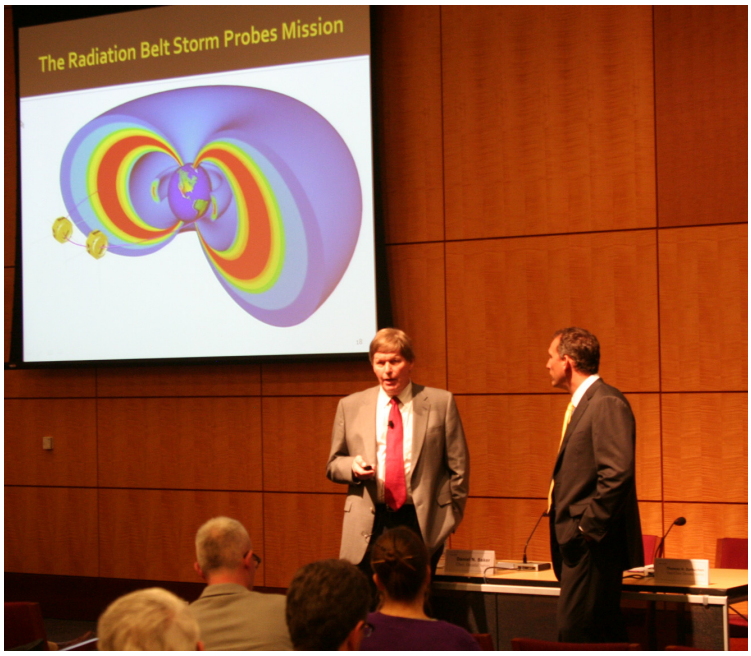
STUDY COMMITTEES

Initial dissemination activities for the **Planetary Science Decadal Survey,** *Vision and Voyages for Planetary Science in the Decade 2013 -2022,* were concluded at the end of August following the release of an illustrated version of the survey report intended for a popular audience. The illustrated booklet and the full survey report are both available at <http://www.nap.edu/catalog.php?record_id=13117>; follow the "Report in Brief" link to view the booklet. The survey report is also available on a single DVD. Copies of the illustrated booklet are available from the SSB (see the last page of this newsletter). Continuing dissemination of *Vision and Voyages* will continue under the aegis of the Committee on Astrobiology and Planetary Science.

Solar and Space Physics: A Science for a Technological Society, the NRC's second decadal survey in solar and space physics from the ad hoc **Committee on A Decadal Strategy for Solar and Space Physics (Heliophysics),** outlines programs, initiatives, and investments in the field that will promote fundamental advances in scientific knowledge of the space environment—from the interior of the Sun, to the atmosphere of Earth, to "space weather." Considering scientific value, urgency, cost, risk, and technical readiness, the report identifies the highest priority targets for 2013-2022. A prepublication version of the report was released on August 15, 2012, at a press event that was also recorded by NASA TV <http://www.nasa.gov/mission_pages/sunearth/news/decadal-2012.html>. The report has briefed to senior officials at NASA Headquarters; NASA Goddard Space Flight Center; NSF; NOAA; Johns Hopkins Applied Physics Laboratory as well as to staff of OMB, OSTP, and the Senate Commerce Committee, House Science Committee, Senate Appropriations Subcommittee on Commerce, Justice, Science, and Related Agencies; and the House Appropriations Subcommittee on Commerce, Justice, Science, and Related Agencies. Detailed information about the survey is available at <http://sites.nationalacademies.org/SSB/CurrentProjects/SSB_056864>. The report is available at <http://www.nap.edu/catalog.php?record_id=13060>.

The **Committee on Planetary Protection Standards for Icy Bodies in the Solar System** has completed its activities, and copies of its report, *Assessment of Planetary Protection Requirements for Spacecraft Missions to Icy Solar System Bodies*, are available upon request.

The ad hoc **Committee on the Assessment of NASA's Earth Science Program** was formed to review the alignment of the NASA Earth Science Division's program with previous NRC advice, primarily the 2007 decadal survey report *Earth Science and Applications from Space*. The committee was directed to neither revisit nor alter the scientific priorities or mission recommendations provided in the decadal survey and related NRC reports; however, the committee was invited to provide guidance about implementing the recommended mission portfolio in preparation for the next decadal survey. The final version of the committee's report, *Earth Science and Applications from Space: A Midterm Assessment of NASA's Implementation of the Decadal Survey,* has now been published. Online and PDF versions of the report are available at <http://www.nap.edu/catalog.php?record_id=13405>.

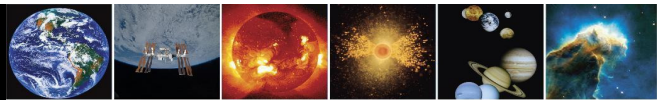


Daniel Baker (chair) and Thomas Zurbuchen (vice chair) at the press conference for the release of the decadal survey in solar and space physics on August 15, 2012 at the Keck Center of the National Academies in Washington, DC.

The prepublication version of *The Effects of Solar Variability on Earth's Climate: A Workshop Report,* delivered to NSF and NASA on September 13 and publically released on September 19, is available at <http://www.nap.edu/catalog.php?record_id=13519>. The final report is being readied for printing.

The **Committee for the Implementation of a Sustained Land Imaging Program** held a writing meeting on June 4 in Irvine, CA, and is planning a final writing meeting to complete their draft report on October 23-24, in Santa Barbara, CA. The prepublication report is expected to be delivered in early 2013. More information is available at <http://sites.nationalacademies.org/SSB/CurrentProjects/SSB_065886>.

Following the transfer of funds from NASA to the NRC, the human spaceflight study commenced on August 1, 2012, and the recruitment process for the ad hoc **Committee on Human Spaceflight** is currently underway and nearing completion. William J. Perry, Stanford University, and Jonathan Lunine, Cornell University, have been appointed as co-chairs of the study. Prior to the start of the study, and under a separate initiation task, leading candidates were identified for positions on both the steering committee and the technical feasibility panel. A wide spectrum of cultural, political, economic and technical issues, critical to the charge envisioned by NASA and Congress, continues to be weighed during the recruitment process. Work also continued in this period on assembling and organizing an extensive reference collection for the



SSB ACTIVITIES, CONTINUED

study, and outreach and coordination are continuing with stakeholder groups and individuals in the U.S. and international communities. Internal planning and coordination work was also conducted during this period across the NRC boards and divisions conducting the study.

The parent division of SSB and ASEB, the Division on Engineering and Physical Sciences (DEPS), has been asked to conduct a comprehensive, agency-wide assessment of NASA's strategic direction. ASEB and SSB staff are helping to manage the **NASA's Strategic Direction** study for DEPS. The committee held meetings on May 1-2, June 25-27, and July 26-27 (all in Washington, DC) and on August 6-7 (Irvine, CA). The committee held its fifth and final meeting on September 20-21 (Irvine, CA) and is drafting its report. In addition to its regular meetings, committee members have also visited all of the NASA field centers, learning about the work they perform and their perspectives on the future of the agency. The committee's final report is expected to enter review soon, with delivery scheduled for after the November elections.

OTHER ACTIVITIES

The **Committee on Space Research (COSPAR)** will hold its next scientific assembly at the Lomonosov Moscow State University in Moscow, Russia, on August 2-10, 2014 (see page 8). The inaugural COSPAR Symposium will be held in Bangkok, Thailand, on November 11-15, 2013 (see page 9 for additional details). The annual round of COSPAR business meetings will be held at COSPAR Headquarters in Paris, France, on March 18-21 , 2013.

SSB staff members attended and distributed materials at the **Division on Planetary Science** (AAS) 44th Annual meeting on October 14-19 in Reno, NV. In conjunction with the NRC's Division on Earth and Life Sciences (DELS), the SSB will be represented at an exhibit booth at the **American Geophysical Union** (AGU) Fall Conference in San Francisco, CA, on December 3-7. In addition, we will exhibit at the 221st **American Astronomical Society** (AAS) meeting in Long Beach, CA, on January 6-10, 2013, in partnership with the Board and Astronomy and Astrophysics.

Board and Committee Member News

The American Geophysical Union (AGU) has invited LASP Director **Daniel Baker** to deliver a Bowie lecture at its 2012 Fall Meeting in San Francisco, CA, this December. Designation as a Bowie lecturer is the highest honor in each of the AGU scientific sections. Baker will deliver the Van Allen lecture in the Space Physics and Aeronomy section of the Bowie series; his talk is titled "Magnetospheric Exploration: Basic Research with a High Public Purpose."

LLOYD V. BERKNER SPACE POLICY INTERNSHIPS

WE ARE CURRENTLY ACCEPTING APPLICATIONS FOR INTERNSHIPS FOR THE SUMMER 2013 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 program is open to both undergraduate and graduate students.

The SSB is now accepting applications from undergraduates for its summer 2013 program. The deadline for applications is February 1, 2012. Successful candidates will be contacted no later than March 1, 2013.

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 and basic research techniques (familiarity with Microsoft Word, Excel, and PowerPoint, as well as HTML, is highly desirable but not essential).*

NOTE: SELECTION OF INTERNS 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.

Preview of the First COSPAR Symposia: Bangkok 2013

The growing size and complexity of the biennial COSPAR scientific assemblies has been an issue of concern to the organization's leadership for several years. The assemblies have become so large that some have argued that only the major space-faring nations possess the large, modern conference facilities needed to host plenary events with 2,000-3,000 participants and 30-plus parallel sessions. Thus, the concern is that COSPAR may be sliding into a two-tier structure of member nations that can and cannot host a scientific assembly.

This concern led to a proposal for a new type of meeting focusing on education and the affairs of emerging space powers. This new activity, dubbed the COSPAR Symposium, was initially discussed by the COSPAR Bureau and Council in Bremen in 2010 and remanded to an ad hoc group for additional discussion (with input from both member organizations and associates). Proponents of symposia argue that they are designed to achieve the following:

- Assist COSPAR to offer opportunities to countries with small to medium-size space programs to hold space research-related events;
- Promote the continuing expansion of space programs worldwide, with a particularly dynamic trend in emerging and developing countries; and,
- Direct a portion of COSPAR cash reserves into new initiatives in favor of the development of space research.

The COSPAR Symposium would have the following characteristics:

- Differ clearly from the scientific assemblies and minimize perceived competition with them;
- Be held in odd years, with the first being held as early in 2013;
- Have a clear thematic focus and a distinctly multidisciplinary/interdisciplinary character;
- Avoid scheduling conflict with other events organized by other relevant ICSU groups and partner organizations; and
- Be organized in a manner that does not give added work to the leadership of COSPAR's Scientific Commissions and, thus, not impact preparations for the scientific assemblies.

The COSPAR Symposium will differ from the scientific assemblies in the following areas:

- Convene in countries without a large space infrastructure;
- Aim to attract between 500 and 1,000 participants, perhaps with a regional focus;
- Focus on a small number of interdisciplinary events and/or sessions featuring the latest results from new missions;
- Feature training, educational, capacity-building, and outreach events specifically oriented toward the needs of teachers, students, young professionals and the general public;
- Last no more than 4 days; and
- Require registration fees approximately one-third of that for a scientific assembly.

The COSPAR Bureau decided during its meeting in March 2011 to hold one symposium on a trial basis and then to decide, based on practical experience, whether or not to attempt any more. Later that year, COSPAR issued a call for proposals for the hosting of an initial symposium in 2013, and comprehensive bids were received from Poland and Thailand. The Thai proposal was subsequently judged to be the one most consistent with the symposium concept.

The outlines for the event were defined during the first meeting of the Symposium Program Committee (SPC) in March 2012. The SPC is chaired by Boonrucksar Soonthornthum and consists of representatives from Thailand's sponsoring organizations—the Geo-Informatics and Space Technology Development Agency and the National Astronomical Research Institute of Thailand—and representatives from participating COSPAR scientific commissions and panels. The basic theme of the symposium will be "Planetary Systems of Our Sun and Other Stars, and the Future of Space Astronomy." The symposium will take place at the Centara Grand in Bangkok on November 11-15 , 2013.

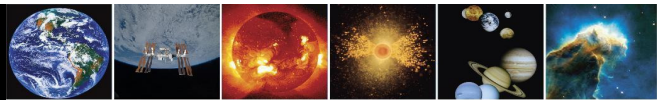
According to information made available during the Scientific Assembly in Mysore this past summer, the Bangkok Symposium will feature plenary, parallel, and poster sessions devoted to the following topics:

- Comparative planetology—including physical studies of the terrestrial and giant planets; atmospheric dynamics of Jupiter, Mars, and Earth; Titan and Earth ocean structure; and orbit impact on planetary climate.
- The future of space astronomy.
- Missions and techniques—including advanced measurement techniques, observations, calibration, inversion, space observations, and advanced retrieval techniques.
- Astrobiology—including the origin, evolution, distribution, and future of life in the universe.
- Small bodies in the solar system, exoplanets, and other solar systems—including direct observations and theoretical studies and early solar system evolution.
- Citizen science, outreach, education, amateur astronomy, and scientific ballooning.

In addition, the symposium will include training sessions on topics related to the interplanetary magnetic field, energetic particle transport, magnetospheres, and space weather effects. A capacity-building workshop addressing topics concerning Earth remote sensing in general, and atmospheric corrections and soundings and radar observations in particular, will be held the week before the symposium.

Registration will open on May 1, 2013. Abstracts may be submitted until May 31, 2013. Additional information can be found at <http://cospar2013.gistda.or.th>.

David Smith, SSB Senior Program Officer and Executive Secretary for COSPAR



COSPAR 2014

40th Scientific Assembly of the Committee on Space Research (COSPAR) and Associated Events

August 2 - 10, 2014
Moscow, Russia

Scientific Program Chair: Prof. M.I. Panasyuk, Moscow State University

Abstract Deadline: Mid-February 2014

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- SC A: The Earth's Surface, Meteorology and Climate
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- SC D: Space Plasmas in the Solar System, Including Planetary Magnetospheres
- SC E: Research in Astrophysics from Space
- SC F: Life Sciences as Related to Space
- SC G: Materials Sciences in Space
- SC H: Fundamental Physics in Space
- Panel on Satellite Dynamics (PSD)
- Panel on Scientific Ballooning (PSB)
- Panel on Potentially Environmentally Detrimental Activities in Space (PEDAS)
- Panel on Radiation Belt Environment Modelling (PRBEM)
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NEW RELEASES FROM THE SSB

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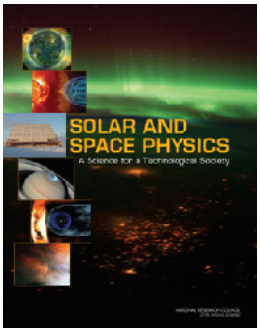


Solar and Space Physics: A Science for a Technological Society

The prepublication version of this report of the ad hoc Committee on a Decadal Strategy for Solar and Space Physics (Heliophysics) was publically released on August 15, 2012, and is available at <http://www.nap.edu/catalog.php?record_id=13060>. The study was led by Chair Daniel N. Baker, University of Colorado, Boulder, and Vice Chair Thomas H. Zurbuchen, University of Michigan, and staffed by Study Director Arthur A. Charo and Associate Program Officer Abigail A. Sheffer, as well as Program Officer Maureen Mellody, Research Associate Lewis Groswald, Senior Program Assistants Terri Baker and Linda M. Walker, Lloyd V. Berkner Space Policy Intern Danielle Piskorz, and National Academies Christine Mirzayan Science and Technology Policy Fellows Bruno Sánchez-Andrade Nuño and Heather D. Smith. Other staff are listed in the report.

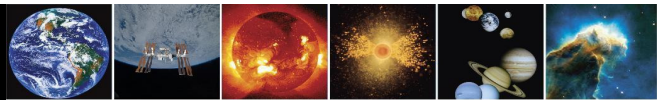
Summary

From the interior of the Sun, to the upper atmosphere and near-space environment of Earth, and outward to a region far beyond Pluto where the Sun's influence wanes, advances during the past decade in space physics and solar physics—the disciplines NASA refers to as heliophysics—have yielded spectacular insights into the phenomena that affect our home in space. This report, from the National Research Council's (NRC's) Committee for a Decadal Strategy in Solar and Space Physics, is the second NRC decadal survey in heliophysics. Building on the research accomplishments realized over the past decade, the report presents a program of basic and applied research for the period 2013-2022 that will improve scientific understanding of the mechanisms that drive the Sun's activity and the fundamental physical processes underlying near-Earth plasma dynamics, determine the physical interactions of Earth's atmospheric layers in the context of the connected Sun-Earth system, and enhance greatly the capability to provide realistic and specific forecasts of Earth's space environment that will better serve the needs of society. Although the recommended program is directed primarily to NASA (Science Mission Directorate –Heliophysics Division) and the National Science Foundation (NSF) (Directorate for Geosciences–Atmospheric and Geospace Sciences) for action, the report also recommends actions by other federal agencies, especially the National Oceanic and Atmospheric Administration (NOAA) those parts of NOAA charged with the day-to-day (operational) forecast of space weather. In addition to the recommendations included in this summary, related recommendations are presented in the main text of the report.

RECENT PROGRESS: SIGNIFICANT ADVANCES FROM THE PAST DECADE

As summarized in Chapter 3 and discussed in greater detail in Chapters 8-10, the disciplines of solar and space physics have made remarkable advances over the last decade—many of which have come from the implementation of the program recommended in the 2003 solar and space physics decadal survey. Listed below are some of the highlights from an exciting decade of discovery:

- New insights, gained from novel observations and advances in theory, modeling, and computation, into the variability of the mechanisms that generate the Sun's magnetic field, and into the structure of that field;
- A new understanding of the unexpectedly deep minimum in solar activity;
- Significant progress in understanding the origin and evolution of the solar wind;
- Striking advances in understanding both explosive solar flares and the coronal mass ejections that drive space weather;
- Groundbreaking discoveries about the surprising nature of the boundary between the heliosphere—that is, the immense magnetic bubble containing our solar system—and the surrounding interstellar medium;
- New imaging methods that permit researchers to directly observe space weather-driven changes in the particles and magnetic fields surrounding Earth;
- Significantly deeper knowledge of the numerous processes involved in the acceleration and loss of particles in Earth's radiation belts;
- Major advances in understanding the structure, dynamics, and linkages in other planetary magnetospheres, especially those of Mercury, Jupiter, and Saturn;
- New understanding of how oxygen from Earth's own atmosphere contributes to space storms;
- The surprising discovery that conditions in near-Earth space are linked strongly to the terrestrial weather and climate below;
- The emergence of a long-term decline in the density of Earth's upper atmosphere, indicative of planetary change; and
- New understanding of the temporal and spatial scales involved in magnetospheric-atmospheric coupling in Earth's aurora.



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It is noteworthy that some of the most surprising discoveries of the past decade have come from comparatively small missions that were tightly cost-constrained, competitively selected, and principal investigator (PI)-led—recommendations in the present decadal survey reflect this insight.

Enabled by advances in scientific understanding as well as fruitful interagency partnerships, the capabilities of models that predict space weather impacts on Earth have also made rapid gains over the past decade. Reflecting these advances and a society increasingly vulnerable to the adverse effects of space weather, the number of users of space weather services has also grown rapidly. Indeed, a growing community has come to depend on constant and immediate access to space weather information (Chapter 7).

SCIENCE GOALS FOR THE NEXT DECADE

The significant achievements of the past decade set the stage for *transformative* advances in solar and space physics for the coming decade. Reports from the survey's three interdisciplinary study panels (Chapters 8-10) enumerate the key scientific opportunities and challenges for the coming decade; collectively, they inform the survey's four overarching science goals, each of which is considered of equal priority:

Goal 1. Determine the origins of the Sun's activity and predict the variations in the space environment.

Goal 2. Determine the dynamics and coupling of Earth's magnetosphere, ionosphere, and atmosphere and their response to solar and terrestrial inputs.

Goal 3. Determine the interaction of the Sun with the solar system and the interstellar medium.

Goal 4. Discover and characterize fundamental processes that occur both within the heliosphere and throughout the universe.

GUIDING PRINCIPLES AND PROGRAMMATIC CHALLENGES

To achieve these science goals, the survey committee recommends adherence to the following principles (Chapter 1):

- To make transformational scientific progress, the Sun, Earth, and heliosphere must be studied as a coupled system;
- To understand the coupled system requires that each subdiscipline be able to make measurable advances in achieving its key science goals; and
- Success across the entire field requires that the various elements of solar and space physics research programs—the enabling foundation comprising theory, modeling, data analysis, innovation, and education, as well as ground-based facilities and small-, medium-, and large-class space missions—be deployed with careful attention both to the mix of assets and to the schedule (cadence) that optimizes their utility over time.

The committee's recommendations reflect these principles while also taking into account issues of cost, schedule, and complexity. The committee also recognizes a number of challenges that could impede achievement of the recommended program: the assumed budget may not be realized or missions could experience cost growth; the necessity to coordinate activities across multiple agencies; and the limited availability of appropriately sized and affordable space launch vehicles, particularly medium-class launch vehicles.

RECOMMENDATIONS—RESEARCH AND APPLICATIONS

The survey committee's recommendations are listed in Tables S.1 and S.2; a more complete discussion of the "research" recommendations—the primary focus of this survey—is found in Chapter 4 along with a discussion of the "applications" recommendations, while Chapter 7 presents the committee's vision, premised on the availability of additional funds, of an expanded program in space weather and space climatology. The committee's recommendations are prioritized and integrated across agencies to form an effective set of programs consistent with fiscal and other constraints. An explicit cost appraisal for each NASA research recommendation is incorporated into the budget for the overall program (Chapter 6); however, for NSF programs, only a general discussion of expected costs is provided (Chapter 5).

Research Recommendations

Baseline Priority for NASA and NSF: Complete the Current Program

The survey committee's recommended program for NSF and NASA assumes continued support in the near term for the key existing program elements that constitute the Heliophysics Systems Observatory (HSO) and successful implementation of programs in advanced stages of development.

NASA's existing heliophysics flight missions and NSF's ground-based facilities form a network of observing platforms that operate simultaneously to investigate the solar system. This array can be thought of as a single observatory—the Heliophysics System Observatory (HSO) (see Figure 1.2). The evolving HSO lies at the heart of the field of solar and space physics and provides a rich source of observations that can be used to address increasingly interdisciplinary and long-term scientific questions. Missions now under development will expand the HSO and drive scientific discovery. For NASA, these include the following:

- The Radiation Belt Storm Probes (RBSP, Living With a Star (LWS) program, 2012 launch) and related Balloon Array for RBSP Relativistic Electron Losses (BARREL; first launch 2013) will determine the mechanisms that control the energy, intensity, spatial distribution, and time variability of Earth's radiation belts.
- The Interface Region Imaging Spectrograph (IRIS; Explorer program, 2013 launch) will deliver pioneering observations of chromospheric dynamics just above the solar surface to help determine their role in the origin of the heat and mass fluxes into the corona and wind.
- The Magnetospheric Multiscale mission (MMS; Solar-Terrestrial Probe (STP) program, 2014 launch) will address the physics of magnetic reconnection at the previously inaccessible tiny scale where reconnection is triggered.

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Compelling missions that are not yet in advanced stages of development but are part of a baseline program whose continuation NASA asked the survey committee to assume include the following:

- Solar Orbiter (European Space Agency-NASA partnership, 2017 launch) will investigate links between the solar surface, corona, and inner heliosphere from as close as 62 solar radii.
- Solar Probe Plus (SPP, LWS program, 2018 launch) will make mankind's first visit to the solar corona to discover how the corona is heated, how the solar wind is accelerated, and how the Sun accelerates particles to high energy.

With these new investments, the powerful fleet of space missions that explore our local cosmos can be significantly strengthened. However, implementation of the baseline program will consume nearly all of the resources anticipated to be available for new starts within NASA's Heliophysics Division through the midpoint of the overall survey period, 2013-2022.

For NSF, the previous decade witnessed the initial deployment in Alaska of the Advanced Modular Incoherent Scatter Radar (AMISR), a mobile facility used to study the upper atmosphere and to observe space weather events, and the initial development of the Advanced Technology Solar Telescope (ATST), a 4-meter-aperture optical solar telescope—by far the largest in the world—that will provide the most highly resolved measurements ever obtained of the Sun's plasma and magnetic field. These new NSF facilities join a broad range of existing ground-based assets that provide an essential global synoptic perspective and complement space-based measurements of the solar and space physics system. With adequate science and operations support, they will enable frontier research even as they add to the long-term record necessary for analyzing space climate over solar cycles.

R1.0 Implement the DRIVE Initiative

The survey committee recommends implementation of a new, integrated, multiagency initiative (DRIVE—Diversify, Realize, Integrate, Venture, Educate) that will develop more fully and employ more effectively the many experimental and theoretical assets at NASA, NSF, and other agencies.

The DRIVE initiative encompasses specific, cost-effective, augmentations to NASA and NSF heliophysics programs. Its implementation will bring existing "enabling" programs to full fruition and will provide new opportunities to realize scientific discoveries from existing data, build more comprehensive models, make theoretical breakthroughs, and innovate. With this in mind, the committee has as its first priority for both NASA and NSF (after completion of the current program) the implementation of an integrated, multiagency initiative comprising the following components:

- Diversify observing platforms with microsatellites and mid-scale ground-based assets
- Realize scientific potential by sufficiently funding operations and data analysis
- Integrate observing platforms and strengthen ties between agency disciplines
- Venture forward with science centers and instrument and technology development
- Educate, empower, and inspire the next generation of space researchers

The five DRIVE components are defined in Chapter 4, with specific and actionable recommendations for each element. Implementation of the NASA portion of the DRIVE initiative would require an augmentation to existing program lines equivalent to approximately $33 million in current (2013) dollars (see Chapter 6). The cost and implementation of the NSF portion of DRIVE are described in Chapter 5. Although the recommendations for NSF within the DRIVE initiative are not prioritized, the survey committee calls attention to two in particular:

The National Science Foundation should:

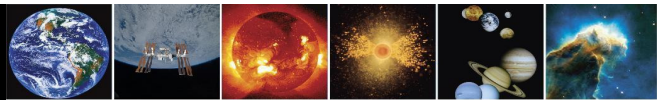
Provide funding sufficient for essential synoptic observations and for efficient and scientifically productive operation of the Advanced Technology Solar Telescope (ATST), which provides a revolutionary new window on the solar magnetic atmosphere.

Create a new competitively selected mid-scale project funding line in order to enable mid-scale projects and instrumentation for large projects. There are a number of compelling candidates for a mid-scale facilities line, including the Frequency Agile Solar Radiotelescope (FASR), the Coronal Solar Magnetism Observatory (COSMO), and several other projects exemplifying the kind of creative approaches necessary to fill gaps in observational capabilities and to move the survey's integrated science plan forward.

R2.0 Accelerate and Expand the Heliophysics Explorer Program

The survey committee recommends that NASA accelerate and expand the Heliophysics Explorer program. Augmenting the current program by $70 million per year, in fiscal year 2012 dollars, will restore the option of Mid-size Explorer (MIDEX) missions and allow them to be offered alternately with Small Explorer (SMEX) missions every 2 to 3 years. As part of the augmented Explorer program, NASA should support regular selections of Missions of Opportunity.

The Explorer program's strength lies in its ability to respond rapidly to new concepts and developments in science, as well as in the program's synergistic relationship with larger-class strategic missions. The Explorer mission line has proven to be an outstanding success, delivering—cost-effectively—science results of great consequence. The committee recommends increased support of the Explorer program to enable significant scientific advances in solar and space physics. As discussed in Chapter 4, the committee believes that the proper cadence for Heliophysics Explorers is one mission every 2 to 3 years. The committee's recommended augmentation of the Explorer program would facilitate this cadence and would also allow selection of both small- and medium-class Explorers. Historically, MIDEX missions offered an opportunity to resolve many of the highest-level science questions, but they have not been feasible with the current Explorer budget.



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Regular selections of Missions of Opportunity will also allow **the research community to respond quickly and to leverage limited resources with interagency, international, and commercial flight partnerships. For relatively modest investments, such opportunities can potentially address high-priority science aims identified in this survey.**

R3.0 Restructure Solar-Terrestrial Probes as a Moderate-Scale, PI-Led Line

The survey committee recommends that NASA's Solar-Terrestrial Probes program be restructured as a moderate-scale, competed, principal-investigator-led (PI-led) mission line that is cost-capped at $520 million per mission in fiscal year 2012 dollars including full life-cycle costs.

NASA's Planetary Science Division has demonstrated success in implementing mid-size missions as competed, cost-capped, PI-led investigations via the Discovery and New Frontiers programs. These are managed in a manner similar to Explorers and have a superior cost-performance history relative to that of larger flagship missions. The committee concluded that STP missions should be managed likewise, with the PI empowered to make scientific and mission design trade-offs necessary to remain within the cost cap (Chapter 4). With larger-class LWS missions and smaller-class Explorers and Missions of Opportunity, this new approach will lead to a more balanced and effective overall NASA HPD mission portfolio that is implemented at a higher cadence and provides the vitality needed to accomplish the breadth of the survey's science goals. The eventual recommended minimum cadence of STP missions is one every 4 years.

Although the new STP program would involve moderate missions being chosen competitively, the survey committee recommends that their science targets be ordered as follows so as to systematically advance understanding of the full coupled solar-terrestrial system:

R3.1 The first new STP science target is to understand the outer heliosphere and its interaction with the interstellar medium, as illustrated by the reference mission Interstellar Mapping and Acceleration Probe (IMAP; Chapter 4). Implementing IMAP as the first of the STP investigations will ensure coordination with NASA Voyager missions. The mission implementation also requires measurements of the critical solar wind inputs to the terrestrial system.

R3.2 The second STP science target is to provide a comprehensive understanding of the variability in space weather driven by lower-atmosphere weather on Earth. This target is illustrated by the reference mission Dynamical Neutral Atmosphere-Ionosphere Coupling (DYNAMIC; Chapter 4).

R3.3 The third STP science target is to determine how the magnetosphere-ionosphere-thermosphere system is coupled and how it responds to solar and magnetospheric forcing. This target is illustrated by the reference mission Magnetosphere Energetics, Dynamics, and Ionospheric Coupling Investigation (MEDICI; Chapter 4).

The rationale for all the selections and for their ordering is detailed in Chapter 4.

Living With a Star

Certain landmark scientific problems are of such scope and complexity that they can be addressed only with major missions. In the survey committee's plan, major heliophysics missions would be implemented within NASA's LWS program; the survey committee recommends that they continue to be managed and executed by NASA centers. Other integral thematic elements besides the flight program are essential to the LWS science and technology program: the unique LWS research, technology, strategic capabilities, and education programs remain of great value.

R4.0 Implement a large Living With a Star mission to study the ionosphere-thermosphere-mesosphere system in an integrated fashion.

The survey committee recommends that, following the launch of RBSP and SPP, the next LWS science target focus on how Earth's atmosphere absorbs solar wind energy. The recommended reference mission is Geospace Dynamics Constellation (GDC).

As detailed in Chapter 4, the GDC reference mission would provide crucial scientific measurements of the extreme variability of conditions in near-Earth space. Within anticipated budgets, the completion of the baseline LWS program, which includes the launch of two major missions—RBSP in 2012 and SPP in 2018—does not allow for the launch of a subsequent major mission in heliophysics until 2024, 6 years after SPP. This establishes what the survey committee regards as the absolute minimum needed cadence for major missions.

APPLICATIONS RECOMMENDATIONS: ENABLING EFFECTIVE SPACE WEATHER AND CLIMATOLOGY CAPABILITIES

Multiple agencies of the federal government have vital interests related to space weather, and efforts to coordinate these agencies' activities are seen in the National Space Weather Program (NSWP). Nonetheless, the survey committee concluded that additional approaches are needed to develop the capabilities outlined in the 2010 National Space Policy document and envisioned in the 2010 NSWP plan. Chapter 7 presents the committee's vision for a renewed national commitment to a comprehensive program in space weather and climatology (SWaC). Enabling an effective SWaC capability will require action across multiple agencies and an integrated program that builds on the strengths of individual agencies.

A1.0 Recharter the National Space Weather Program

The survey committee recommends that, to coordinate the development of this plan, the National Space Weather Program should be rechartered under the auspices of the National Science and Technology Council and should include the active participation of the Office of Science and Technology Policy and the Office of Management and Budget. The plan should build on current agency efforts, leverage the new capabilities and knowledge that will arise from implementation of the programs recommended in this report, and develop additional capabilities,

(Continued from page 13)

on the ground and in space, that are specifically tailored to space weather monitoring and prediction.

A2.0 Work in a multi-agency partnership to achieve continuity of solar and solar wind observations.

The survey committee recommends that NASA, NOAA, and the Department of Defense work in partnership to plan for continuity of solar and solar wind observations beyond the lifetimes of ACE, SOHO, STEREO, and SDO. In particular:

A2.1 Solar wind measurements from L1 should be continued, because they are essential for space weather operations and research. The DSCOVR and IMAP STP missions are recommended for the near term, but plans should be made to ensure that measurements from L1 continue uninterrupted into the future.

A2.2 Space-based coronagraph and solar magnetic field measurements should likewise be continued.

Further, the survey committee concluded that a national, multifaceted program of both observations and modeling is needed to transition research into operations more effectively by fully leveraging expertise from different agencies, universities, and industry and by avoiding duplication of effort. This effort should include determining the operationally optimal set of observations and modeling tools and how best to effect that transition. With these objectives in mind:

A2.3 The space weather community should evaluate new observations, platforms, and locations that have the potential to provide improved space weather services. In addition, the utility of employing newly emerging information dissemination system for space weather alerts should be assessed.

A2.4 NOAA should establish a space weather research program to effectively transition research to operations.

A2.5 Distinct funding lines for basic space physics research and for space weather specification and forecasting need to be developed and maintained.

Implementation of a program to advance space weather and climatology will require funding well above what the survey committee assumes will be available to support its research-related recommendations to NASA (see Table S.1). The committee emphasizes that implementation of an initiative in space weather and climatology should proceed only if it does not impinge on the development and timely execution of the recommended research program.

RECOMMENDED PROGRAM, DECISION RULES, AND AUGMENTATION PRIORITIES FOR NASA

Recommended Program

The committee's recommended program for NASA Heliophysics Division is shown in Figure S.1. As detailed in Chapter 6, the plan restores the medium-class Explorers and, together with small-class Explorer missions and Missions of Opportunity, achieves the recommended minimum mission cadence. The plan also begins the DRIVE initiative as early in the decade as budgets allow, with full implementation achieved by mid-decade. However, funding constraints affect the restoration and recommended rebalance of heliophysics program elements such that full realization of the survey committee's strategy is not possible until after 2017 (Figure S.1).

Decision Rules to Ensure Balanced Progress is Maintained

The recommended program for NASA cost-effectively addresses key science objectives. However, the survey committee recognizes that the already tightly constrained program could face further budgetary challenges. For example, with launch planned in 2018, the Solar Probe Plus project has not yet entered the implementation phase when expenditures are highest. Significant cost growth in this very important, but technically challenging, mission beyond the current cap has the potential to disrupt the overall NASA heliophysics program.

To guide the allocation of reduced resources, the committee recommends the following decision rules intended to provide flexibility and efficiency if funding is less than anticipated, or should some other disruptive event occur. These rules, discussed in greater depth in Chapter 6, maintain progress toward the top-priority, system-wide science challenges identified in this survey. The decision rules should be applied in the order shown to minimize disruption of higher-priority program elements:

Decision Rule 1. Missions in the STP and LWS lines should be reduced in scope or delayed to accomplish higher priorities (Chapter 6 gives explicit triggers for review of Solar Probe Plus).

Decision Rule 2. If further reductions are needed, the recommended increase in the cadence of Explorer missions should be scaled back, with the current cadence maintained as the minimum.

Decision Rule 3. If still further reductions are needed, the DRIVE augmentation profile should be delayed, with the current level of support for elements in the NASA research line maintained as the minimum.

Augmentations to Increase Program Value

The committee notes that the resources assumed in crafting this decadal survey's recommended programs are barely sufficient to make adequate progress in solar and space physics; with reduced resources, progress will be inadequate. It is also evident that with increased resources, the pace at which the nation pursues its program could be accelerated with a concomitant increase in the achievement of scientific discovery and societal value. The committee recommends the following augmentation priorities to aid in implementing a program under a more favorable budgetary environment:

Augmentation Priority 1. Given additional budget authority early in the decade, the implementation of the DRIVE initiative should be accelerated.

Augmentation Priority 2. With sufficient funds throughout the decade, the Explorer line should be further augmented to in-

(Continued from page 14)

crease the cadence and funding available for missions, including Missions of Opportunity.

Augmentation Priority 3. Given further budget augmentation, the schedule of STP missions should advance to allow the third STP science target (MEDICI) to begin in this decade.

Augmentation Priority 4. The next LWS mission (GDC) should be implemented with an accelerated, more cost-effective funding profile.

EXPECTED BENEFITS OF THE RECOMMENDED PROGRAM

Implementation of the survey committee's recommended programs will ensure that the United States maintains its leadership in solar and space physics and, the committee believes, lead to significant—even transformative—advances in scientific understanding and observational capabilities (Table S.3). In turn, these advances will support critical national needs for information that can be used to anticipate, recognize, and mitigate space weather effects that threaten to human life and the technological systems society depends on. ■

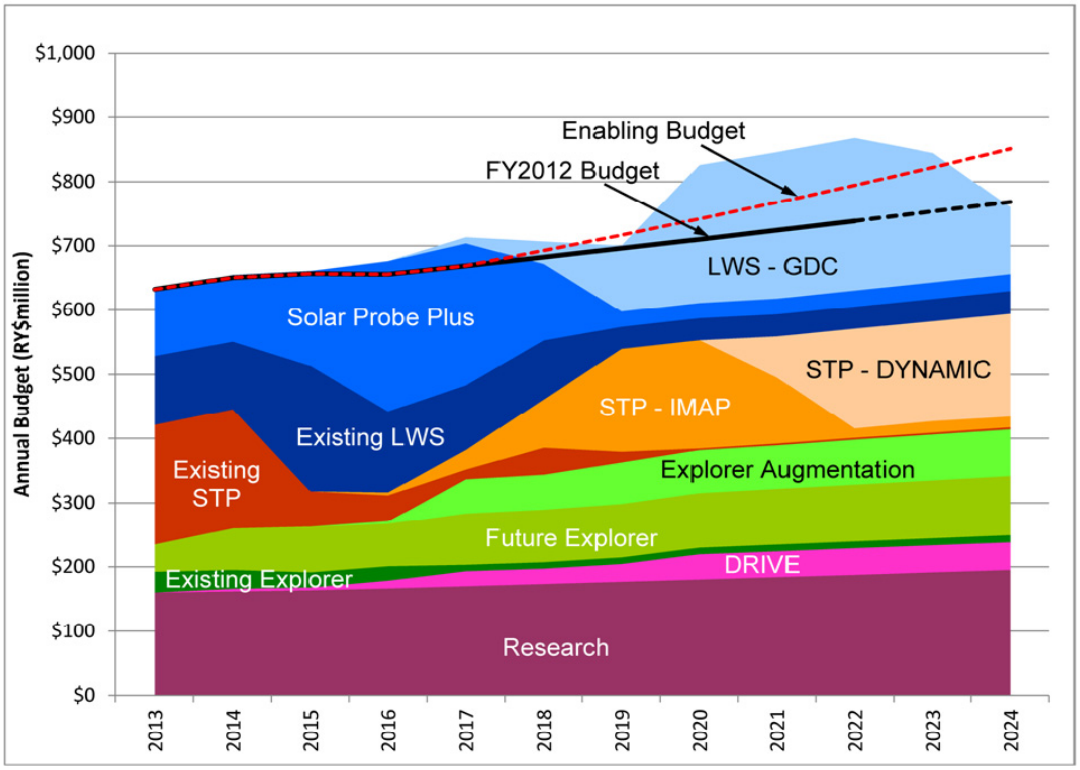
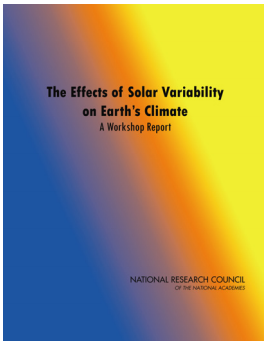


FIGURE S.1 The committee's recommended program for NASA Heliophysics Division for the years 2013-2024 is shown by category in the figure above. The plan restores the medium-class Explorers and, together with small-class Explorer missions and Missions of Opportunity, achieves the recommended minimum mission cadence. The committee's recommended new starts in the restructured Solar-Terrestrial Probes (STP) mission line and the Living With a Star Program (LWS) also begin in the latter part of the decadal survey interval. The solid black line in the figure indicates the funding level from 2013 to 2022 provided to the committee by NASA as the baseline for budget planning, and the dashed black line extrapolates the budget forward to 2024. After 2017, the amount increases with a nominal 2% inflationary factor. The red dashed "Enabling Budget" line includes a modest increase from the baseline budget starting in 2017, allowing implementation of the survey-recommended program at a more efficient cadence that better meets scientific and societal needs and improves optimization of the mix of small and large missions. From 2017 to 2024 the Enabling Budget grows at 1.5% above inflation. If necessary, GDC implementation could be stretched (at some cost) to conform to the projected funding profile.

NEW RELEASES FROM THE SSB, CONTINUED



The Effects of Solar Variability on Earth's Climate: A Workshop Report

The prepublication version of this workshop report of the ad hoc Committee on the Effects of Solar Variability on Earth's Climate was publically released on September 19, 2012, and is available at <http://www.nap.edu/catalog.php?record_id=13519>. The workshop was led by Chair Gerald R. North, Texas A&M University, and staffed by Study Director Abigail A. Sheffer, Senior Program Officer Arthur A. Charo, Research Associate Amanda R. Thibault, Senior Program Assistant Terri M. Baker, Program Associate Dionna Williams, and Lloyd V. Berkner Space Policy Interns Michael Barton and Danielle Piskorz . Other staff are listed in the report.

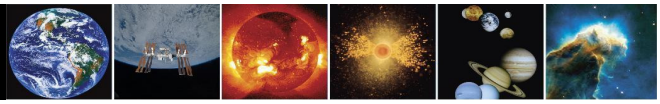
Overview

Solar irradiance, the flux of the Sun's output directed toward Earth, is Earth's main energy source.[1] The Sun itself varies on several timescales—over billions of years its luminosity increases as it evolves on the main sequence toward becoming a red giant; about every 11 years its sunspot activity cycles; and within just minutes flares can erupt and release massive amounts of energy. Most of the fluctuations from tens to thousands of years are associated with changes in the solar magnetic field. The focus of the National Research Council's September 2011 workshop on solar variability and Earth's climate, and of this summary report, is mainly magnetically driven variability and its possible connection with Earth's climate variations in the past 10,000 years. Even small variations in the amount or distribution of energy received at Earth can have a major influence on Earth's climate when they persist for decades. However, no satellite measurements have indicated that solar output and variability have contributed in a significant way to the increase in global mean temperature in the last 50 years.[2,3,4] Locally, however, correlations between solar activity and variations in average weather may stand out beyond the global trend; such has been argued to be the case for the El Niño-Southern Oscillation, even in the present day.

A key area of inquiry deals with establishing a unified record of the solar output and solar-modified particles that extends from the present to the prescientific past. The workshop focused attention on the need for a better understanding of the links between indices of solar activity such as cosmogenic isotopes and solar irradiance. A number of presentations focused on the timescale of the solar cycle and of the satellite record, and on the problem of extending this record back in time. Highlights included a report of progress on pyroheliometer calibration, leading to greater confidence in the time history and future stability of total solar irradiance (TSI), and surprising results on changes in spectral irradiance over the last solar cycle, which elicited spirited discussion. New perspectives on connections between features of the quiet and active areas of the photosphere and variations in TSI were also presented, emphasizing the importance of developing better understanding in order to extrapolate back in time using activity indices. Workshop participants' reviews highlighted difficulties as well as causes for optimism in current understanding of the cosmogenic isotope record and the use of observed variability in Sun-like stars in reconstructing variations in TSI occurring on lower frequencies than the sunspot cycle.

The workshop succeeded in bringing together informed, focused presentations on major drivers of the Sun-climate connection. The importance of the solar cycle as a unique quasi-periodic probe of climate responses on a timescale between the seasonal and Milankovitch cycles was recognized in several presentations. The signal need only be detectable, not dominant, for it to play this role of a useful probe. Some workshop participants also found encouraging progress in the "top-down" perspective, according to which solar variability affects surface climate by first perturbing the stratosphere, which then forces the troposphere and surface. This work is now informing and being informed by research on tropospheric responses to the Antarctic ozone hole and volcanic aerosols. In contrast to the top-down perspective is the "bottom-up" view that the interaction of solar energy with the ocean and surface leads to changes in dynamics and temperature. During the discussion of how dynamical air-sea coupling in the tropical Pacific and solar variability interact from a bottom-up perspective, several participants remarked on the wealth of open research questions in the dynamics of the climatic response to TSI and spectral variability.

The discussion of the paleoclimate record emphasized that the link between solar variability and Earth's climate is multifaceted and that some components are understood better than others. According to two presenters on paleoclimate, there is a need to study the idiosyncrasies of each key proxy record. Yet they also emphasized that there may be an emerging pattern of paleoclimate change coincident with periods of solar activity and inactivity, but only on long timescales of multiple decades to millennia. Several speakers discussed the effects of particle events and cosmic-ray variability. These are all areas of exciting fundamental research; however, they have not yet led to conclusive evidence for significant related climate effects. The key problem of attribution of climate variability on the timescales of the Little Ice Age and the Maunder Minimum were directly addressed in several presentations. Several workshop participants remarked that the combination of solar, paleoclimatic, and climate modeling research has the potential to dramatically improve the credibility of these attribution studies. ■



(Continued from page 3)

minimize the challenge. First of all, it means developing a solid base of new technology and a heavy-lift launch vehicle in this decade. That is challenge enough, but human beings will have to survive away from Earth for years; the biomedical and radiation hazards must be faced, and we do not understand how we will deal with these problems. To me, the subtlest challenge of all is to learn how to sustain the enterprise for the decades it will take to accomplish its mission. This means settling on clear, fundamental goals that can endure despite the inevitable ups and downs that occur while they are being achieved.

Many people believe that Mars is the ultimate goal for human exploration, and, indeed, the 2010 Act recognizes that "*A long term objective for human exploration of space should be the eventual international exploration of Mars.*" This fact alone makes it clear that NASA's Mars science and human exploration programs have a powerful mutual interest in working together. The key issue right now is to develop a clear set of goals where collaboration enhances leadership for both science and exploration. Otherwise, a relationship that has been fraught with difficulty in the past could again go awry. Fortunately, I see a new spirit of cooperation, and there is reason to be optimistic. That said, it is clear that NASA's space science program is under considerable stress. The past year has witnessed, for example, the disruption, if not outright abandonment of, scientific strategies that have been constructed over many years for the future exploration of Mars and outer planetary bodies such as Europa. And, in the process, international agreements highly advantageous to the research community, NASA, and the nation were set aside.

Space Science

The 2010 Act instructs NASA to take into account the current NRC decadal surveys when submitting the President's budget request to the Congress. So let me spend a little time reflecting on the current situation there.

The recently completed NRC decadal surveys and related studies, taken together, provide an up-to-date overview of the state of American space science. The study teams sought the views of their disciplinary communities by soliciting hundreds of white papers and conducting dozens of town hall meetings. The decadal survey teams included experienced managers and engineers, as well as scientists, and made independent estimates of cost and technical risk so as to make financially responsible recommendations. In all cases, however, the process started with identifying the most important scientific goals for the coming decade. Some of the financial assumptions may have been overtaken by the recent budgetary turmoil, but the goals behind the specifics still shine through. It is these I relate here, especially those whose achievement is critical to leadership in the coming decades.

(Continued on page 18)

News from the National Academies

C.D. (Dan) Mote Jr. Nominated to Be Next NAE President

The National Academy of Engineering (NAE) 2013 nominating committee unanimously recommended C.D. (Dan) Mote Jr., past president and Regents Professor of the University of Maryland (UMD), to stand as the sole candidate for the NAE presidency. NAE members will vote in March 2013 to elect a new NAE president to a 6-year term beginning July 1.

Neil Armstrong 1930-2012

Neil Armstrong, the first person ever to step onto another planetary body died on August 25, 2012 . His words spoken during the 1969 Apollo 11 mission to Earth's moon—"That is one small step for (a) man, one giant leap for mankind"—instantly became a part of history. Those few words from the Sea of Tranquility, NASA stated on its website, were the climactic fulfillment of the efforts and hopes of millions of people and the expenditure of billions of dollars.

A member of the National Academy of Engineering, Armstrong contributed his expertise to several Academies projects, and most recently served as a member of the Aeronautics and Space Engineering Board's Committee to Assess NASA's Aeronautics Flight Research Capabilities. The report of this committee, *Recapturing NASA's Aeronautics Flight Research Capabilities,* has been reissued in his honor.

His NASA obituary can be found at <http://www.nasa.gov/topics/people/features/armstrong_obit.html>.

This reissue, dedicated to Neil A. Armstrong—aviator, educator, and pioneer in aeronautics—1930-2012, is available from the Aeronautics and Space Engineering Board (aseb@nas.edu).

(Continued from page 17)

American leadership in space astronomy and astrophysics is solid, but not unchallenged. The Hubble Space Telescope, the Nobel-winning Cosmic Background Explorer, and 20 years of systematically planned missions to study the sky in every accessible wavelength range, from microwaves to gamma rays, have kept research in these fields on the forefront. This leadership is ours to lose. First and foremost, we must stay the course and complete the James Webb Space Telescope (JWST). I think neither the scientific community nor Congress knew how challenging (and expensive) this mission would become, but stopping now would have serious consequences for the whole field. Many of us recall that the U.S. lost leadership in particle physics to Europe when the Superconducting Supercollider was cancelled. We cannot let the same thing happen to JWST, which will do in the 21st century what Hubble did in the 20th. Next, we should capture the benefits of pioneering American breakthroughs in dark energy by accomplishing the goals of the Wide-Field Infrared Survey Telescope (WFIRST), the first priority mission in the NRC decadal survey *New Worlds, New Horizons* and a highly capable mission that has an equally compelling science goal in the discovery of extrasolar planets. Completion of JWST may delay their accomplishment, but if we do not pursue Earth observation enterprise needs the country to agree on a stable, motivating vision like those that keep astronomers and physicists returning to the same questions for decades until they get answered.

Planetary science is leadership science in its essence. Simply getting to another planet is a major challenge, and landing on one is where the United States is a complete master, as *Curiosity* shows; the U.S. is also the undisputed, but not unchallenged, leader in the orbital exploration of the outer planets and their satellites. My colleague Steve Squyres can make these points with much more authority than I, since he chaired *Vision and Voyages,* SSB's recent decadal survey in planetary science. Here I restrict myself to a few general remarks. His committee's report identifies the highest-priority mission being one that would begin the process of returning samples from Mars. The report emphasizes the importance of maintaining a balanced program and describes promising smaller missions and the supporting activities necessary to make these programs successful with strong support for the New Frontiers and Discover classes of missions. Many people have praised *Vision and Voyages* for its succinct set of "decision rules" designed to help cope with changing budgetary circumstances.

Curiosity, because it has a long-lasting nuclear power source, could produce world-class science throughout the coming decade, but unfortunately there is now a question of what comes after that for Mars. *Curiosity* is the product of a program strategy developed in the late 1990's to answer a first-class scientific question: What did water on Mars do in the past, and where is it now, and is there evidence for organic molecules? (Water and organic molecules were, after all, the prerequisites for life on Earth). Recently, the next two missions consistent with this strategy—The Mars Trace Gas Orbiter and the Mars Astrobiology Explorer-Cacher— were cancelled; whatever the issues of risk and financial prudence that might have motivated this decision, it sends a chill through the Mars science community and its many followers in the public. The near future looks bright, but what will come after the launch of MAVEN1 in 2013 and InSight2 in 2016? Will we be able to keep the team together? Fortunately, *Visions and Voyages* points to a guiding direction for Mars science exploration. Missions should contribute to the goal of sample return, so that one day hundreds of scientific laboratories on Earth can be put to work broadening the scientific beachhead our landers are occupying.

NASA has assembled an internal team to identify an integrated strategy for the agency's Mars Exploration Program in light of current funding constraints. NASA has said that team's initial focus will be on a possible 2018-2020 robotic mission as part of a program whose framework will be developed in consultation with the science community and international partners, and which aims to advance the priorities in the *Vision and Voyages* decadal survey. This team's report is expected to be released soon, and we at the SSB with our Committee on Astrobiology and Planetary Science stand ready to assist in ensuring that the eventual program pursues the carefully developed priorities of the decadal survey—priorities that are the result of a 2-year process that represents the

consensus position of the scientific community on a balanced planetary science program that will produce, as Steve Squyres has said many times, the best science return per dollar for the Nation.

I have highlighted where I see opportunities for leadership in each of NASA's main areas of space endeavor. I have had to gloss over the many other less visible, but in total equally essential, activities that contribute to excellence. These may be found in the reports themselves. But there is one more requirement for leadership that can be found in every report: *balance*. Balance means different things in each area, but basically it means that we should not put all our eggs in one basket. Also, balance definitely does not mean "something for everybody!" Smaller spacecraft missions, sub-orbital flights, modeling, data analysis, and research grants sustain the quality of the disciplines that originate the great leadership projects. It is striking to me that each of our committees put its recommendation for balance on an equal footing with its first-priority leadership mission.

What does this mean for you as legislators? Keep in mind that when you support leadership projects, you are investing in the spirit of innovation, and when you support balance, you are investing in the capacity to innovate.

Never before has congressional leadership been more critical to America's leadership in space than now. Now is the time for you to shape enduring goals that can guide America's space program to its next stage of leadership in the complex times you see ahead. The space science and technology community can deal with budgetary turbulence, but only when there is a stable sense of direction.

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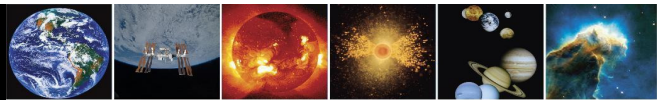
1 Mars Atmosphere and Volatile Evolution, the second and final Mars Scout mission.

2 Interior Exploration using Seismic Investigations, Geodesy and Heat Transport, the next Discovery mission. ■



SUMMARY—MEETING OF INTEREST

2012 Space Security Index Executive Summary Launch July 17, 2012

This summary has been prepared by SSB Intern Michael Barton as a factual summary of what occurred at the meeting. The statements made are those of the author and do not represent the views of the participants, the Space Studies Board, or the National Academies. Note that only a summary of the Index overview is included here, not a summary of the panel discussion.

Go to the Space Security website at <http://www.spacesecurity.org/ *for additional information and to view the Space Security Index.*

The Secure World Foundation and the Canadian Embassy hosted a launch conference for the 2012 Space Security Index Executive Summary. The Space Security Index (SSI) provides a significant benefit as we track utilization of space globally. It provides a concrete means to measure annual progress in space security. SSI 2012 is the 9th edition of SSI, and as always, it encourages fresh international discussions at COPUOS and other forums about how to secure access to space and protect from space-based threats that dissolve boundaries among nations and create mutual vulnerabilities. There are four themes in this year's SSI:

1. Physical Space Environment. There are now more than 17,000 pieces of space debris greater than 10 cm out of 300,000 pieces total, concentrated in high-value orbits. Debris is having an increasing impact on operational spacecraft, as seen in the fourteen close approach alerts on the International Space Station this year. The increasing space debris is fueling investment in space situational awareness (SSA), the practice of tracking and identifying all objects in space to determine their intent and their effect on assets. Data sharing is vital in the field of SSA because no one state has sufficient SSA capabilities to protect their assets, and this year the United States is strengthening the SSA Sharing Program.

2. Laws, Policies, and Doctrines. The normative policy architecture that exists today, anchored by the 40-year-old Outer Space Treaty, is insufficient. The ongoing arguments are whether policies should be national or multilateral and if they should be legally binding or politically binding "rules of the road." As examples, the proposed International Code of Conduct would be politically binding, whereas the draft Treaty on the Prevention of the Placement of Weapons in Outer Space and the Threat or Use of Force against Outer Space Objects (PPWT) would be legally binding.

3. Number and Diversity of Space Actors. The number of actors is on the rise as nine states now have independent launch capabilities and a large number of non-governmental organizations (NGOs) and academic institutions are now involved in space as well. The rate of involvement will only increase as the barriers to space are removed worldwide. The limited nature of some space resources such as GEO slots and RF spectrum means that governance will be needed to ensure that all actors are treated fairly. The satellite industry is positioned for growth, as the market did not experience the downturn that was forecasted because of the global economy's downturn. The industry expects that more than 1,000 satellites will be produced between 2011 and 2021, leading to over $200 billion in revenue.

4. Military. There are over 165 dedicated military satellites used for navigation, intelligence, surveillance, and reconnaissance, with half owned by the United States and a fourth owned by Russia. There are still no space-based weapons. This year saw an increase dual-use spacecraft that have commercial or civil and military functions, as well as an increase in the importance of the ground cyber network. ■

SUMMARIES OF CONGRESSIONAL HEARINGS OF INTEREST

Spurring Economic Growth and Competitiveness through NASA-Derived Technologies

July 12, 2012
U.S. House of Representatives
Committee on Science, Space, and Technology
Subcommittee on Space and Aeronautics

Witnesses: Dr. Mason Peck, NASA Chief Technologist; Mr. George Beck, Chief Clinical and Technology Officer, Impact Instrumentation, Inc.; Mr. Brian Russell, Chief Executive Officer, Zephyr Technology; Mr. John Vilja, Vice President for Strategy, Innovation and Growth, Pratt & Whitney Rocketdyne; Dr. Richard Aubrecht, Vice President, Moog, Inc.

Archived webcast, statements, and charter are available at <http://science.house.gov/hearing/subcommittee-space-and-aeronautics-hearing-spurring-economic-growth-and-competitiveness>

This summary has been prepared by SSB Intern Michael Barton as a factual summary of what occurred at the meeting. The statements made are those of the author and do not represent the views of the participants, the Space Studies Board, or the National Academies.

Subcommittee Chair Rep. Steven Palazzo (R-MS) mentioned in his opening statement that there have been over 1,700 successful NASA technology transfers since 1976, but that NASA technology has seen a decline in recent years, leading to missed opportunities for industry and the public to benefit from NASA-derived technologies. A recent NASA Inspector General report (IG-12-013) criticized NASA technology transfer efforts, generating enough interest on the Hill to set up this hearing. While Dr. Mason Peck, the NASA Chief Technologist, stated that NASA HQ agrees with the findings of the IG and that the Office of the Chief Technologist (OCT) is leveraging the report to make improvements to training procedures and ease of use, there seemed to be more interest in learning about the spinoffs and the value of NASA technology transfer.

Dr. Peck gave an overview of the responsibilities of OCT, which takes on the hard questions of space and aeronautics, learns how to solve them, and shares with the public technological advances

(Continued from page 19)

that NASA makes that lead directly to improvements in manufacturing efficiency, advanced medicine, agricultural yields, transportation, solar and wind energy, biomedical applications, protective gear for military, and efficiency in aeronautics. Peck said, "The challenges of the space program create new ideas to drive nation's economy, make America unique, motivate the future, and provide success to businesses." Examples can be found at <http://spinoff.nasa.gov>, but Peck mentioned an advanced portable ultrasound that requires minimal expertise, a phototropic cell for water purification that can clean up wastewater and environmental hazards, and the CMOS chip developed at JPL that powers all of our cell phone cameras. Peck noted that over the past 10 years, NASA spinoffs have created 14,000 jobs, generated $5 billion in revenue, and saved 400,000 lives. He emphasized that continual investment in NASA technology was vital for great spinoffs.

The other panelists were from companies that partnered with NASA to develop technologies. Mr. George Beck from Impact Instrumentation, Inc., described the life support ventilator systems that were sold to NASA for use on ISS and then improved upon through a Space Act Agreement (called a spin-in) for the benefit of astronauts, war fighters, and private citizens. He said that the biggest leverage of working with NASA was the cultivation of a new generation of engineers and researchers. Mr. Brian Russell from Zephyr Technology partnered with NASA Ames to develop a bioharness for astronauts and troops that tracks vitals of a group of people, presents it real time to a user, and saves it for analysis. It is now in use for training by the Department of Homeland Security, U.S. Special Forces, Olympians, the National Basketball Association, Formula 1, and college athletics departments. Zephyr also worked with NASA to provide critical health monitoring of the Chilean miners, and this data is now being used at NASA as an analogue to long-duration missions without access to medical attention. Russell mentioned that working for NASA is about not only receiving funding, but also receiving knowledge and support from veteran engineers. Mr. John Vilja from Pratt & Whitney Rocketdyne (PWR) talked about how his company is leveraging their work with NASA on rocket engines and applying it to the energy industry. Applying their NASA-derived knowledge of high-pressure systems in small spaces is leading to a compact coal gassifer that reduces capital and end product costs by about 20% while reducing water usage by 30%. Their thermal management expertise is leading to the world's first solar energy plant that stores excess energy during the day so it can produce base power 24/7. Dr. Richard Aubrecht from Moog, Inc., explained how its partnership with NASA during the creation of the space shuttle redundant flight control system has been leveraged to the point where they are the global leader in the field. Their company is providing the flight control actuation for the F-35, the Boeing 787, and the Airbus A350.

Aubrecht urged Congress to fund NASA consistently and to give NASA goals with timetables so that partnering companies can build and retain design engineering capabilities. Both Vilja and Aubrecht stated that it was critical for NASA to continue programs to fruition so that companies can market the NASA-proven technology. Futhermore, Aubrecht said that NASA has performed best when it had very clear objectives that everyone could understand. This ensured that everyone was on the same page, while also allowing for better public outreach.

Rep. Hansen Clarke (D-MI), discussing bringing jobs to Detroit, asked how companies could get past the barriers, and how NASA could more quickly transfer technology. Russell advised that it is better for a company to know what problem they can solve and then engage with NASA researchers directly, rather than attack the bureaucratic process from the outset. Peck spoke about the new web-based interfaces that OCT has implemented to cut down on the bureaucracy and remove the barriers of technology transfer. ■

The International Space Station: A Platform for Research, Collaboration, and Discovery

July 25, 2012

U.S. Senate Committee on Commerce, Science, and Transportation

Witnesses: Mr. William Gerstenmaier, NASA Associate Administrator, Human Exploration and Operations; Dr. Donald Pettit, NASA Astronaut; Mr. James Royston, Interim Executive Director, Center for the Advancement of Science in Space; Mr. Thomas Reiter, Director, ESA Directorate of Human Spaceflight and Operations

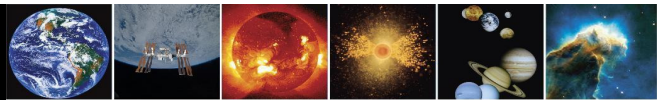
Archived webcast and statements are available at <http://commerce.senate.gov/public/index.cfm?p=Hearings>.

This summary has been prepared by SSB Intern Michael Barton as a factual summary of what occurred at the meeting. The statements made are those of the author and do not represent the views of the participants, the Space Studies Board, or the National Academies.

Senator Hutchison (R-TX) requested a hearing to examine the progress of and impediments to research aboard the International Space Station (ISS) and to inform the public on the great work being done. Thanks to the work of Senator Hutchison, the Destiny Laboratory module has been designated a National Laboratory, opening up the ISS to outside entities to do research that would not be possible anywhere else.

The senators present welcomed Dr. Don Pettit back to Earth, as he landed after a 6-month stay aboard the ISS. Pettit stated that he is honored to be part of NASA's group of explorers. One of the responsibilities of an explorer is to come back and tell stories that inform and inspire the public. These stories hinge on the explorer's position on the frontier, where the answers are not in the back of the book. Exploring is the only way to discover the works of nature, which has an imagination greater than humans have, and to Pettit a metric of how viable your nation is.

The committee also heard from a representative from the European Space Agency (ESA) for the first time in a decade. Mr. Reiter stated that Europe decided to engage as a partner in the ISS because of research utilization potential. ESA operates the Columbus multi-function laboratory with 10 payload racks, provides the Automated Transfer Vehicle that can carry 7 metric tons of cargo to the ISS, and has sent 18 crewmembers since 2001. ESA has performed more than 200 experiments involving thousands of scientists across the member countries. Reiter also stated that the ISS provides a test bed for international partners to work together on sending



SUMMARIES OF CONGRESSIONAL HEARINGS OF INTEREST, *CONTINUED*

beyond Earth orbit.

Senator Nelson (D-FL) stated that the ISS, which has a pressurized volume equal to that of a Boeing 747, has been continuously crewed since 2000, it is only now becoming operational, and that it would be shortsighted to think that the United States would end the ISS mission in 2020 as authorized. When asked if NASA is looking at extending the life, Gerstenmaier stated that NASA and the international partners are studying the technical barriers to extending the program to 2028. NASA thinks it will be okay, but the team is still looking at structural life and other things. Gerstenmaier also said that in the next 2 years ISS utilization needs to improve because the station needs to show results to sell the extension to all the governments involved. Pettit explained that right now astronauts spend 6.5 hours out a 14-hour workday on programmatic activities and that this ratio is commensurate with other frontier programs that put humans in inhospitable areas such as deep sea and Antarctic research. Reiter expects the next 2years of operation will increase research optimization.

Mr. James Royston of Center for the Advancement of Science in Space (CASIS), the non-profit company charged with maximizing the utilization of the ISS National Lab, reported that CASIS is now shifting from its standup phase, where it spread the word about the facility while building a solid foundation of customers, to operations. By streamlining NASA procedures and handling all of the technical reviews required for space operations, CASIS is convincing new companies to propose work on the ISS, from start-ups up to Fortune 500 companies. The goal is show companies that working at the ISS National Lab is just as easy as working at any other National Lab that is 300 miles away (only the ISS is 300 miles away vertically). CASIS has met all of its key milestones in its performance plan and will announce a board of directors very soon that will consist of leading scientists and business leaders.

Expedition 31 crew inside SpaceX Dragon, NASA image ISS031-E-078305.

Senator Rubio asked the panel to help him explain to others what types of innovations justify the expenditure for ISS. Royston remarked that the four markets for CASIS are life science, material science, physical science, and Earth observation. Pettit spoke on the work NASA is doing to solve the mysteries of astronaut eye maladies and bone loss, while Gerstenmaier spoke on the vaccines that are being developed for salmonella and MRSA based on microgravity virus growth. Reiter spoke about new lightweight alloys used for turbine blades developed on the ISS. Pettit talked about basic combustion research being done in the absence of gravity and convection. Gerstenmaier said that for Earth observation, the ISS is the best way to optimize sensors quickly. Pettit stated that often it takes a human in the loop to figure out what you actually want to measure.

Also during the hearing, Senators Nelson and Hutchison paid tribute to the great life and work of Dr. Sally Ride, NASA's first female astronaut. ■

STAFF NEWS

Division on Engineering and Physical Sciences 2011 Annual Staff Achievement Awards

Staff members were honored at the 11th Annual DEPS Staff Achievement Awards in May. **Sandra Graham** received the Exceptional Achievement Award and a Team Award was given to the ASEB/SSB Administrative Team—**Terri Baker, Rodney Howard, Andrea Rebholz, Linda Walker**, and **Dionna Williams**.

Staff Changes

Terri Baker, Senior Project Assistant, accepted a position with the Transportation Research Board. Terri worked most recently on the Decadal Strategy for Solar and Space Physics (Heliophysics) and the Committee on Assessment of Impediments to Interagency Cooperation on Space and Earth Science Missions. We wish her well in her new endeavors.

Lloyd V. Berkner Space Policy Internship

The goal of the Lloyd V. Berkner Space Policy Internship 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 can be found on at <http://sites.nationalacademies.org/SSB/ssb_052239>. In February 2013 the SSB will begin accepting applications for the Summer 2013 program (see page 7). Past interns reflect on their internship on page 22 of this newsletter.

STAFF NEWS, CONTINUED

From Our Interns

Michael Barton *completed his assignment with the SSB as a Summer 2012 Lloyd V. Berkner Space Policy Intern. His reflections on his experience with the SSB appear below.*

My time at the Space Studies Board was everything I had hoped it would be and more. As an undergraduate aerospace engineer, the more I learned about the space industry, the more I realized that engineers did not run it; instead, the policymakers make most of the decisions. I wanted to study this intersection of scientists/engineers and policymakers through the Lloyd V. Berkner Space Policy internship, and I was not disappointed. The internship allowed me to dive headfirst into the space policy arena, learning how the technical community interacts with lawmakers.

When I was offered the internship, I assumed that I would get to sit in on meetings and hear about some key players in the field, but I could not imagine the summer the National Academies had in store for me! The SSB gave me an inside look into the arena that I was hoping for, but the depth and richness of my experiences over the summer was more than I expected. I had the chance to visit two NASA centers and two embassies for various space functions, meet several former NASA administrators as well as Buzz Aldrin, and hear about the latest plans for future NASA science missions. Those things, however, were just the icing on the cake! I spent the summer learning about the SSB's committees and report processes first-hand—from committee selection, to meetings, to publication, including the famous response to review task. I staffed and prepared extensive background documents and meeting reports for several SSB space science standing committees and the NRC Committee on NASA's Strategic Direction. These background document assignments allowed me to research in-depth the history of NASA and policy-makers success in guiding the agency over the decades. I was also able to attend and write brief articles on several congressional hearings and briefings, which showed me how personality affects policy. The best part was that I was able to spend substantial time with space policy experts on the SSB staff and throughout Washington D.C., watching and asking questions and learning about what really goes on, where the nation's space policy stands, and where the experts think it is heading.

Miles Lifson *completed his assignment with the SSB as a Summer Intern. His reflections on his experience with the SSB appear below.*

My internship with the SSB plunged me headfirst into the world of space policy and left me with insights that no course or textbook could ever provide. Things started quickly, with the SSB hosting two major meetings of standing committees during my first few weeks. The meetings were an opportunity to learn firsthand from some of the nation's top space scientists. For someone with an interest in the interface between science and government, it was equally valuable to see how these scientists interacted with staffers from Congress, OSTP, and OMB to help guide our nation's scientific priorities, an especially challenging task during times of budgetary austerity. I was fully involved in everything from logistical support to helping prepare summary reports of the meetings . I did not realize how quickly and deeply immersed I had become until my parents began to complain of my excessive use of acronyms unintelligible to the lay person.

My internship took me from congressional hearings, where I was responsible for summarizing information for SSB staff, to space-oriented events at venues ranging from the French Embassy to the Cosmos Club. When I was not out of the office covering events, I was in the office gathering information for committee members ranging from assembling background research on technical and policy matters to lay press accounts of space-relevant topics. Even as an intern, I was fully engaged in high-priority activities like helping to prepare the response-to-review for the forthcoming solar and space physics decadal survey—a key report setting the priorities of the heliophysics research community for the next decade. Even tasks that seemed more routine, like gathering biographic information on speakers for upcoming events, gave me valuable insights, helping me to understand the paths traveled by leading figures in space science and policy to arrive at their current positions.

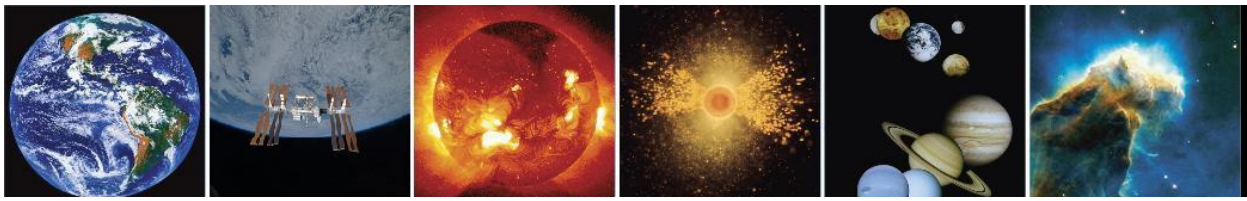
I do not think I will ever forget witnessing the surprise announcement at a meeting of the Committee on Astronomy and Astrophysics of the NRO's donation of two space telescopes to NASA. Seeing press accounts start to appear in real time made me realize I was not just following the news about space, I was in the middle of it.

Thank you to the staff of the SSB and the ASEB for a fascinating, challenging, and truly meaningful internship experience. I know that what I have learned will guide me as I finish my undergraduate degree, and in my education and career plans beyond.

Joseph O'Rourke *completed his assignment with the SSB as a Summer 2012 Lloyd V. Berkner Space Policy Intern. His reflections on his experience with the SSB appear below.*

Without space policy, humanity would be stuck on Earth. Without the Lloyd V. Berkner Space Policy Internship, I would be wallowing in ignorance. Last year, I had a vague notion that a decadal survey was an important thing, having once been assigned a mock white paper by an excited astrophysicist. Now, I've read the reports and met the people who wrote them; I'm eagerly anticipating the SSB's November workshop on lessons learned from all the recent decadal planning processes. My internship fundamentally reshaped my understanding of space policy, the federal budget, and the space exploration community. Days spent reorganizing the SSB subbasement were perhaps less profound, but I enjoyed them anyway. I would like to thank everyone who made these unique opportunities possible.

I've just begun graduate study in planetary science at the California Institute of Technology. Fittingly, one of my projects at the SSB was to digitize the original proposals submitted to the first workshop on NASA's Discovery program in 1992. I ended the summer by drafting sections and hunting down illustrations for the popular version of the 2011 planetary science decadal survey. These two activities reminded me that, while unraveling the mysteries of the solar system may require considerable technical acumen, the wonder of planetary exploration is universal. Assuming that we continue to muster the pecuniary courage to press into the unknown, I look forward to serving our shared vision and to embarking on new voyages of discovery.



SSB Calendar

OCTOBER						
S	M	T	W	Th	F	Sa
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

NOVEMBER						
S	M	T	W	Th	F	Sa
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

DECEMBER						
S	M	T	W	Th	F	Sa
2	3	4	5	6	7	1/8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

November 12-14	Space Studies Board	Irvine, CA
November 12-13	Workshop on Lessons Learned in Decadal Planning in Space Science	Irvine, CA

Future SSB Meetings

March 6-8, 2013, SSB Standing Committee Space Science Week, Washington, DC

April 4-5, 2013, SSB, Washington, DC

August 27-28, 2013, SSB Executive Committee, TBD

November 7-8, 2013, SSB, Irvine, CA

April 3-4, 2014, SSB, Washington, DC

November 5-7, 2014, SSB, Irvine, CA

Visit <http://www.nas.edu/ssb> to stay up to date on board, workshop, and study committee meetings and developments.

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Washington, DC

Arnold and Mabel Beckman Center of the National Academies
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- ☐ Vision an Voyages for Planetary Science (2012) Booklet
- ☐ Solar and Space Physics: A Science for a Technological Society [prepublication] (2012)
- ☐ The Role of Life and Physical Sciences (2012) Booklet
- ☐ Earth Science and Applications from Space: A Midterm Assessment of NASA's Implementation of the Decadal Survey (2012)
- ☐ Assessment of Planetary Protection Requirements for Spacecraft Missions to Icy Solar System Bodies (2012)
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- ☐ Sharing the Adventure with the Public—The Value of Excitement: Summary of a Workshop (2011)
- ☐ Recapturing a Future for Space Exploration: Life and Physical Sciences Research for a New Era (2011) Book and CD
- ☐ Visions and Voyages for Planetary Science in the Decade 2013-2022 (2011) Book and CD
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- ☐ Panel Reports—New Worlds, New Horizons in Astronomy and Astrophysics (2011)
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