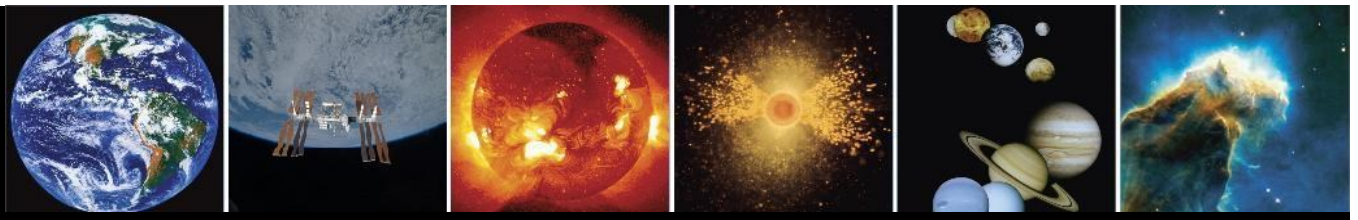
SPACE STUDIES BOARD NEWS



JULY-SEPTEMBER 2013

Inside This Issue

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—SSB Chair Charles F. Kennel

NATIONAL ACADEMY OF SCIENCES
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JULY-SEPTEMBER 2013

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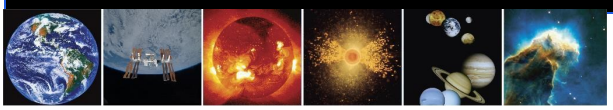


FROM THE CHAIR

As I write, we are several months into the budget sequester, 16 days into the government shutdown, and 12 hours before default on U.S. government debt, with no real resolution in sight to the basic political conflict underlying this impasse. The impact of the shutdown on NASA's day-to-day operations is almost total. Ninety-seven percent of NASA's workforce is on furlough, and NASA's contractor workforce faces an uncertain fate. NASA's websites are down, and researchers all over the world are unable to access NASA data; fortunately, NASA is allowed to keep the astronauts and cosmonauts healthy and active on the International Space Station.

The shutdown will end, but the loss of productivity only makes it all the more difficult to sustain U.S. leadership in space, which was hard enough already given the ongoing effects of flat budgets and sequestration. Even before the present paralysis took hold, NASA was slowly being deprived of oxygen as the conflict over basic political principles reached down to enervate the government's lower levels. Now, you cannot be part of the government without political considerations affecting how you carry out your mission. It has always been important for NASA leadership to respond to the goals of the Administration and Congress. But, at the end of the day, people on both sides of the aisle believed that science—space science—*ought to be* non-political, an attitude that led to some restraint. I wonder whether this is true anymore. I have recently encountered two different political visions of what science NASA should be pursuing. If this continues, there could be real problems. Even the espousal of two scientific visions creates problems in today's conflicted atmosphere. How should NASA's managers navigate between a Republican Scylla and a Democratic Charybdis? Will their programs change dramatically each time an election alters the dominant political philosophy? This is not good for an agency whose projects take years to bring to fruition.

Politicization of science could be one of the more serious fallouts of today's governmental crisis. What can we do in such a circumstance? Before things go too far, I believe it may be time for the National Academies and other professional organizations to reaffirm the authority of science over the goals and findings of scientific research. We on the Space Studies Board have a responsibility to convey the impacts on space and Earth science of policies proposed, actions taken, and opportunities missed, as well as to identify new opportunities. We can be politically aware, but people only listen when we talk about science. What can we say?

American space science leads the world because it has concentrated on fundamental scientific issues. This cannot be said too many times.

Charles F. Kennel
Chair, SSB

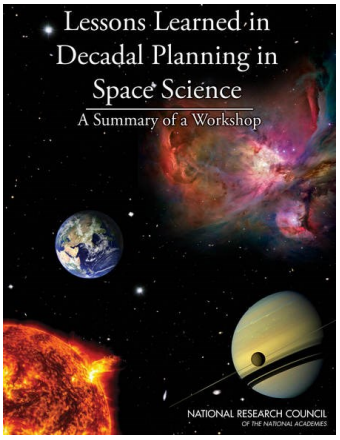
The views expressed here do not necessarily reflect those of the SSB or the National Research Council.

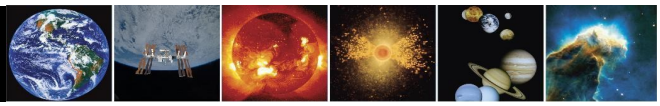
View video and presentations of the recently released workshop summary

Lesson Learned in Decadal Planning in Space Science: A Summary of a Workshop

Download a free copy via the National Academies Press at:
<http://www.nap.edu/catalog.php?record_id=18434>

Videos of the workshop speakers are available for viewing at:
<http://nrc51/SSB/CompletedProjects/SSB_070954>





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Committee on Astrobiology and Planetary Science (CAPS)

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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>

AAS 223RD MEETING
AMERICAN ASTRONOMICAL SOCIETY
WASHINGTON, DC | 5–9 JANUARY 2014

Come visit the SSB at Exhibit Booth 308

AGU FALL MEETING
San Francisco | 9–13 December 2013

Come visit the SSB at Exhibit Booth 307

Did you know.... The American Geophysical Union (AGU) was organized in 1919 to represent the U.S. in the International Research Council's International Union of Geodesy and Geophysics and to serve as the National Research Council Committee on Geophysics. In both of these capacities, the AGU promoted work in the fields of astronomy, geodesy, geology, meteorology, seismology, terrestrial electricity and magnetism, and vulcanology. In 1972, the AGU separated from the National Academies and incorporated as an independent organization. The NRC has an AGU collection that contains correspondence, reports, and meeting minutes covering the years 1919-1965 for a span of 7 linear feet. Learn more at: <http://www.nasonline.org/about-nas/history/archives/collections/agu-1919-1965.html>

SSB ACTIVITIES

THE BOARD AND ITS STANDING COMMITTEES

The **Space Studies Board (SSB)** did not meet this quarter. On July 8 the board held a teleconference with John Grunsfeld, Associate Administrator for the NASA Science Mission Directorate (SMD) and Stephanie Stockman, E/PO (Education/Public Outreach) lead at the SMD to discuss the current budget situation and the changes to SMD's education and outreach programs. The board's Executive Committee met August 8-9 in Washington, DC, where the members held discussions with various stakeholders, including Marc Allen (NASA/SMD); House and Senate Staff, including Tom Hammond, Pamela Whitney, and Ann Zulkosky; and Tammy Dickinson (OSTP). On day 2, the Executive Committee members discussed the upcoming Earth Science and Applications from Space Decadal Survey with the CESAS chair and vice chair and stakeholders, including Mike Freilich (NASA), Mary Kicza (NOAA) and Sarah Ryker (USGS). That was followed by a discussion with Marshall Porterfield (NASA/HEOMD) on a new SSB/ASEB standing committee on biological and physical science. The Board's next meeting will be held November 7-8 in Washington, DC. Visit <http://www.nas.edu/ssb> to stay up to date on board, workshop, and study committee meetings and developments.

The **Committee on Astronomy and Astrophysics (CAA)** did not meet in this quarter, but has been actively planning for its fall meeting to be held in Washington, DC, on November 4-5, 2013. CAA is planning on meeting with key government stakeholders, including NASA Astrophysics Division, NSF Astronomy Division, Department of Energy High Energy Physics Office, and the James Webb Space Telescope Program Office. CAA will also discuss issues pertinent to its charge, including implementation of the 2010 astronomy and astrophysics decadal survey, *New Worlds, New Horizons in Astronomy and Astrophysics*, as well as hear about advances in the field and progress on missions in development.
Additionally, NASA SMD contacted CAA via the SSB to initiate a study to "assess whether NASA's proposed Astrophysics Focused Telescope Assets (AFTA) design reference mission described in the April 30, 2013, report of the AFTA Science Definition Team (SDT), WFIRST-2.4, is responsive to the overall strategy to pursue the science objectives of New Worlds, New Horizons in Astronomy and Astrophysics (NWNH), and in particular, the survey's top-ranked, large-scale, space-based priority: the Wide Field Infrared Survey Telescope (WFIRST)." The Astrophysics Focused Telescope is one of two telescopes given to NASA by the National Reconnaissance Office in 2012. The study was approved in October 2013 by the NRC's Governing Board Executive Committee and will be its own ad hoc activity and will be separate from CAA. Pending availability of study funds from the sponsor, the study is slated to begin in December 2013.
For more information about CAA and to learn about upcoming meetings, please visit <http://sites.nationalacademies.org/BPA/BPA_048755>.

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)

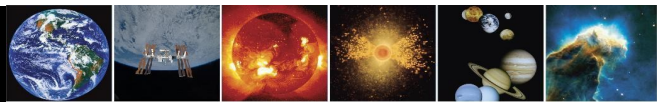
National Research Council's Space Science Week 2014

March 3-5, 2014

National Academy of Sciences Building
2101 Constitution Avenue
Washington, DC

As the quarter ended, the **Committee on Earth Science and Applications from Space (CESAS)** was planning its next in-person meeting, which will take place in Washington, DC, on October 29-30, 2013. During the meeting, the committee will receive briefings from agency officials, including Michael Freilich, head of NASA's Earth Science Division, and Mary Kicza, head of NOAA NESDIS. A briefing on the European Space Agency's (ESA) program in Earth observation science, technology, and applications is also planned. The featured session at this meeting will occur on October 29 when agency representatives and other stakeholders will meet to discuss the organization of the next decadal survey in Earth science and applications from space. Planning for the next decadal, which will cover the approximate period of 2018-2028, will occur throughout 2014 to enable a formal start of the study in early 2015 and publication by mid-2017. For more information about CESAS and to learn about upcoming meetings, please visit <http://sites.nationalacademies.org/SSB/SSB_066587>.

The **Committee on Astrobiology and Planetary Science (CAPS)** met at the National Academies' Keck Center on September 4-6, 2013. The committee was briefed on details of the Mars 2020 Science Definition Team Report and planetary protection, updates on the status of NASA's Planetary Science Division and Astrobiology Program, and updates on the Europa Clipper, NASA's contributions to ESA's JUICE, NASA's Asteroid Redirect Mission, and the Venus Spectral Rocket Experiment missions. The committee also had briefings on the phosphorus chemistry of the early Archean ocean and discussed the proposed STEM reorganization proposals. The first CAPS meeting of 2014 will take place March 3-5 as a part of the NRC's Space Science Week. More information about CAPS is available at <http://sites.nationalacademies.org/SSB/SSB_067577>.



SSB ACTIVITIES, *CONTINUED*

As the quarter ended, the **Committee on Solar and Space Physics** was planning its next in-person meeting, which will take place in Washington, DC, from October 31-November 1, 2013. During the meeting, the committee will receive briefings from agency officials, including the newly appointed head of NASA's Heliophysics Division, David Chenette. Implementation of the decadal survey will be a key topic for discussion during the meeting. The committee also anticipates follow-up discussions related to space weather and further discussions about potential new activities that would be undertaken by ad hoc committees. An edited and final version of Solar and Space Physics: A Science for a Technological Society, the NRC's second decadal survey in solar and space physics (Heliophysics), was published in August 2013. Copies of the report are available for free download at <http://www.nap.edu/catalog.php?record_id=13060> and further information about the study is available at <http://sites.nationalacademies.org/SSB/CurrentProjects/SSB_056864>.

STUDY COMMITTEES

Approval of the membership of Ad Hoc **Committee on A Framework for Analyzing the Needs for Continuity of NASA-Sustained Remote Sensing Observations of the Earth from Space** occurred in August 2013. The committee's first meeting will take place on November 12-14, 2013, in Washington, DC. More information is available at <http://sites.nationalacademies.org/SSB/CurrentProjects/SSB_084713>.

Instruments on NASA research and NOAA "operational" spacecraft measure numerous variables relevant to Earth's biosphere, hydrosphere, atmosphere, and oceans and their interactions on various scales. However, there is a growing tension between the need for measurement continuity of data streams that are critical components of Earth science research programs, (including, but not limited to, areas related to climate), and the development of new measurement capabilities. While there is an increasing societal need for information products derived from Earth observations, the federal agencies responsible for providing these measurements face a near-perfect storm of diminished fiscal resources, (The result of increasing costs, flat or declining budgets, and other challenges, including recovery from the launch failure of OCO and GLORY and the substantive increase in cost, diminished capabilities, and delay of the JPSS spacecraft.) Many Earth-observing satellites are in their extended mission phase nearing the end of their useful lives growth in program costs, and a coming loss of heritage assets.

These circumstances prompted a request from NASA's Earth Science Division (ESD) to the SSB (through CESAS) to assemble an ad hoc committee of the NRC to provide a framework to assist in the determination of when a measurement(s) or dataset(s) initiated by ESD should be collected for extended periods.

Ad hoc **Committee on The Role of High-Power, High Frequency-Band Transmitters in Advancing Ionospheric/Thermospheric Research: A Workshop.**

At the request of the Department of Defense (DOD; Air Force Research Laboratory) and the National Science Foundation (NSF; Directorate for Geosciences/Division of Atmospheric and Geospace Sciences), the SSB held a workshop , "**The Role of High-Power, High Frequency-Band Transmitters in Advancing Ionospheric/Thermospheric Research**"on May 20-21, 2013 in Washington, DC. The workshop provided a forum for information exchange between the comparatively small group of researchers engaged in programs of upper atmospheric research using high-power high-frequency (HF) radar transmitters ("heaters") and the larger ITM (ionosphere-thermosphere-magnetosphere) research community. For a variety of reasons, including the different orientations of DOD, which is primarily interested in applied research related to active ionospheric modification, and the civil agencies, principally NSF, which have broader mandates for basic research, these communities have historically viewed themselves as being distinct with limited overlapping interests.

Per the statement of task, the workshop was organized to consider the utility of heaters in upper atmospheric research in general, with a specific focus on the High-frequency Active Auroral Research Program (HAARP) transmitter facility, which is located in Gakona, Alaska. As the quarter ended, a summary of the workshop was undergoing external peer review. (By design, this report will not include any NRC-approved findings or recommendations.) A pre-publication version of the report is expected to be available in late October or early November 2013. Further information about the workshop, including the membership of the organizing committee, the project statement of task, and the May 2013 workshop agenda, is available at <http://sites.nationalacademies.org/SSB/CurrentProjects/SSB_082082>.

During June and July, Ad Hoc **Committee on Human Spaceflight** solicited input papers from any parties with an interest in human spaceflight. These papers were requested in order to broaden the scope of the committee's information-gathering process, particularly with regard to the benefits and challenges of human spaceflight. Papers submitted to the committee can be downloaded from <http://www8.nationalacademies.org/aseboutreach/publicviewhumanspaceflight.aspx>. The committee met in closed session at Woods Hole, MA, on July 24-26. The committee received progress reports from the Technical Panel and the Public and Stakeholder Opinions Panel, which are supporting the committee, and reviewed white papers submitted by the public and stakeholders. The committee also deliberated on rationales for human spaceflight, development of task statement findings, and on the outline for the committee's final report. In August, a group of members conducted their third site visit to a NASA center (Marshall Space Flight Center). In addition to work that continued in this period via subgroup telecons, the full committee was also briefed by NASA in August on the new version of the Global Exploration Roadmap via an open teleconference call. The committee's next regular meeting took place on October 21-23 in Washington, D.C. The Technical Panel held its final meeting in closed session on October 15-16 in Washington, D.C. The entirety of the October meeting was dedicated to preparing a written summary of the panel's work, to be delivered to the committee at its meeting on October 21-23. Meanwhile, the

SSB ACTIVITIES, *CONTINUED*

Public and Stakeholder Opinions Panel will hold its two final meetings on October 4 and December 12 in Washington, D.C. During this period the Panel worked with the committee to finish its development and testing of a Stakeholder Survey, which then began going out to participants in September. Additional information on this study, including committee and panel meetings, is available at <http://www.nationalacademies.org/humanspaceflight>.

On November 2012, the Space Studies Board—in collaboration with the Board on Physics and Astronomy—held a workshop on **Lessons Learned in Decadal Planning in Space Science** (<http://sites.nationalacademies.org/SSB/CurrentProjects/SSB_070954>). At the workshop, participants reviewed and discussed key aspects of the most recent NRC decadal surveys in space science with the goal of identifying lessons learned and best practices. A summary of that workshop was released this past summer and is available for download at <http://www.nap.edu/catalog.php?record_id=18434>. The summary details the presentations and discussions that transpired at the workshop and is organized around the primary sessions of the workshop. This document will be an important resource for planning the next round of decadal surveys.

The 11-member **Committee on the Assessment of the NASA Science Mission Directorate 2014 Science Plan** was appointed in early August and held its one and only meeting in Irvine, CA, on September 10-12 . A draft of the committee's report was assembled in late-September/early-October and sent to 10 external reviewers on October 3. The committee is currently revising its report in response to reviewer comments, and the public release of the revised document is scheduled for mid-November. Additional details concerning the committee, its membership, and it task is available at <http://sites.nationalacademies.org/SSB/CurrentProjects/SSB_084584>.

OTHER ACTIVITIES

The **Committee on Space Research (COSPAR)** held its annual business meetings in Paris, France, during the week of March 18. The inaugural COSPAR Symposium will be held in Bangkok, Thailand, on November 11-15, 2013. Details concerning the symposium can be found at <http://www.cospar2013.gistda.or.th/index.php>. The next COSPAR scientific assembly will be held at the Lomonosov Moscow State University in Moscow, Russia, on August 2-10, 2014). Preliminary details concerning the Moscow assembly can be found at <https://www.cospar-assembly.org/>. Instructions, details concerning past recipients and nomination forms are available at <https://cosparhq.cnes.fr/awards>.

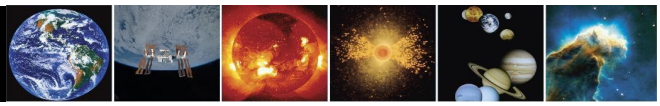
Seeking Input for COSPAR Journal

COSPAR, the Committee on Space Research of the International Council for Science Announces a New Journal: Life Sciences in Space Research

Life Sciences in Space Research will publish high quality original research and state of the art review articles in areas covered by Commission F (life sciences) of COSPAR. The new journal will replace the LS section of Advances in Space Research. Manuscripts in the following areas will be considered:

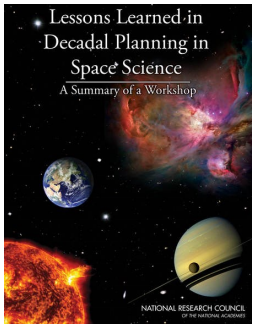
- Effects of space radiation in living organisms at the cellular and molecular levels
- Gravitational effects in biological systems
- Space radiation dosimetry— measurements, modeling and detector development
- Space Radiation risk assessment and countermeasures
- Non-cancer health effects of space radiation, space flight
- Astrobiology
- Prebiotic chemistry and origin of life
- Life in extreme environments
- Habitability in the solar system and beyond
- Ecological life support and sustainability
- Functionality, monitoring and control of ecosystem in space environment
- Animal models in space research
- Effects of space flight conditions on human bodies

COMMITTEE ON SPACE RESEARCH (COSPAR)
Expanding the knowledge frontier of space for the benefit of humankind



NEW RELEASES

Summaries are reproduced from the report here without references, notes, figures, tables, boxes, or attachments.
Copies of reports are available from the SSB office at 202-334-3477 or at <http://www.nap.edu/>.



Lessons Learned in Decadal Planning in Space Science

Lessons Learned in Decadal Planning in Space Science is the summary of a workshop held in response to unforseen challenges that arose in the implementation of the recommendations of the decadal surveys. This report takes a closer look at the decadal survey process and how to improve this essential tool for strategic planning in the Earth and space sciences. Workshop moderators, panelists, and participants lifted up the hood on the decadal survey process and scrutinized every element of the decadal surveys to determine what lessons can be gleaned from recent experiences and applied to the design and execution of future decadal surveys. Lewis Groswald, Associate Program Officer and David H. Smith, Senior Program Officer served as rapporteurs for the Space Studies Board and the Board on Physics and Astronomy. *Other staff are listed in the report.*

Summary of Keynote Speakers Remarks

The first session at the workshop was dedicated to contrasting personal perspectives on the purpose and role of the decadal surveys in the Earth and space science disciplines as tools for strategic planning at NASA. The first perspective was given by Lennard A. Fisk, the Thomas Donahue Distinguished University Professor of Space Science at the University of Michigan and past associate administrator of NASA's former Office of Space Science and Applications. Fisk presents a historical view of the development of the decadal studies from his perspective as both a contributor to and implementer of recommendations contained in survey reports. John Grunsfeld, the current associate administrator of NASA SMD, discusses the challenges of interpreting and implementing decadal survey recommendations in today's scientific and fiscal environment.

AN HISTORICAL PERSPECTIVE ON THE DECADL SURVEY PROCESS

Lennard Fisk opened the keynote session by presenting an historical perspective on the decadal survey process. Noting that an important measure of the success of the surveys is whether programs and missions recommended by the surveys are ultimately implemented, Fisk traced parallel histories of the development of National Research Council (NRC) advice and NASA's evolving response to the advice. Anticipating his conclusions, he warned the audience that the story for recent times is not an especially positive one.

Following the establishment of the Space Science Board in 1958 (which would later be merged with the Space Applications Board in 1989 to form the Space Studies Board), the SSB published the first space science strategy document in 1961 as a comprehensive collection of reports entitled *Science in Space*. The SSB considered itself responsible for determining what science would be pursued in space, but NASA felt otherwise. While the final responsibility for selection of science experiments fell to NASA instead of the SSB, the NRC did retain a strategic role: to recommend what science should be done. Fisk emphasized, "The NASA science program was to be conducted on behalf of all the nation's space scientists." In response to a question later in the workshop, he elaborated to explain that while the space program is conducted on behalf of the nation as a whole, it is the role of the science community to decide what science is to be done.

The first formal decadal survey, which involved broad scientific community input, addressed ground-based astronomy and was issued in 1964 by the NRC Committee on Science and Public Policy. Subsequent NRC surveys in astronomy appeared in 1972 (including a recommendation for the High Energy Astrophysics Observatory) and 1979 (including recommendations for the Great Observatory program of major optical and infrared, x-ray, and gamma ray observatories). All of the recommended major space astronomy missions were ultimately built and launched, albeit at later dates than the surveys envisioned.

Throughout the 1970s and 1980s, the SSB prepared a series of planning documents across a wide range of space science fields. During the same time, NASA began to establish its own network of internal advisory bodies that provided advice to space science program managers, discipline division directors, and the science associate administrator. Thus, these NASA committees enabled the scientific community to be thoroughly involved in the execution of the program and to contribute to a flow of information from the scientific community up and down the NASA management chain.

Fisk described a key milestone for NASA's science budgets at the time of the initiation of the space station program in 1984 when NASA Administrator James Beggs wrote to SSB Chair Thomas Donahue saying that NASA was "willing . . . to commit to budgeting 20 percent of NASA R&D funds for space science and applications, and [to] protect these funds from Space Station development." One important consequence of that commitment was that the NASA headquarters Office of Space Science and Applications (OSSA) had ample resources to manage its program and to set its own course. Thanks, at least in part to the Beggs-Donahue agreement, when the NASA budget doubled from 1988 to 1991, so did the science budget. Consequently, Fisk noted, there was a fertile environment for strategic planning when he became the associate administrator in 1987. In parallel with OSSA's efforts in strategic planning, and with NASA's encouragement, in 1989 the NRC consolidated the SSB and the Space Applications Board so as to form the Space Studies Board, thereby creating a single NRC entity to advise OSSA.

The fourth astronomy decadal survey, published in 1991, endorsed the Space Infrared Telescope Facility (SIRTF) as the fourth of the Great Observatories. However NASA's period of budget growth was coming to an end, and so SIRTF faced descoping and an extended delay before becoming a reality.

Fisk indicated that the early 1990s marked the onset of a new era in NASA management approaches to science programs. Daniel Goldin became NASA administrator in 1992 and broke OSSA into three separate science offices, transferring increased program management responsibility to the NASA field centers, reducing headquarters staff, and emphasizing smaller and faster mission classes. According to Fisk, cost growth problems in the space station program also led to greater oversight into all NASA programs by the Office of Management and Budget in the late 1990s. Goldin was succeeded by Sean O'Keefe in 2000, and after the space shuttle *Columbia* accident, NASA priorities were heavily influenced by President George W. Bush's 2004 Vision for Space Exploration (VSE). Consequently, Mars exploration was accorded an especially high priority while studies of Earth, the Sun, and astrophysics were relegated to a category of activities not directly aligned with the VSE and referred to as "other science."

The next astronomy decadal survey, published in 2001, recommended a balanced program of small-to-large mission sizes and endorsed the Next Generation Space Telescope (now called the James Webb Space Telescope, JWST), but subsequent growth in the JWST program imperiled the recommended balance. An important milestone for the decadal survey process was the development of the first surveys for planetary science and for solar and space physics in 2003.

In 2004 Michael Griffin succeeded O'Keefe as NASA administrator. Fisk noted that Griffin abolished most of NASA's internal advisory committee structure and also espoused a different view of NASA-science community relationships than had been accepted in the past. Namely, Griffin considered the scientific community to be analogous to the aerospace contractor community, and he described the former as "suppliers, not customers." Thus, the tradition of viewing scientists as customers who determine what science is to be pursued was turned on its head, thereby also altering the perspective from which NRC advice could be offered. Griffin did attempt to rebalance the science budgets, but in simultaneously coping with space shuttle and space station cost issues, some $3 billion were removed from the run-out of science budgets, with especially damaging effects in Earth science. Fisk indicated that NASA's internal advisory committee process has not been restored since Charles Bolden succeeded Griffin as administrator in 2009.

The NRC completed the first decadal survey for Earth science and applications from space in 2007. Given the urgency of needs in the program at NASA and the National Oceanic and Atmospheric Administration (NOAA), the survey committee also published an interim report in 2005. Fisk noted that the Obama administration and Congress responded with budget increases, but cost growth in both NASA and NOAA missions continued to present obstacles to fully implementing the survey recommendations.

Fisk described the most recent surveys in astronomy and astrophysics (2010) and planetary science (2011) as being handicapped by budgetary issues. Continuing development costs for JWST have prevented initiation of new missions recommended by the former survey, and budget constraints are preventing initiation of any flagship-class missions recommended by the latter survey. Fisk also observed that while the 2013 survey for solar and space physics is too new for its success to be measured, its prospects may be better because the survey committee took a minimalist approach to the recommended program.

In drawing conclusions from his historical assessment of decadal surveys, Fisk emphasized that two governing principles that have been in place since the beginning—the NRC does the strategic planning, and the NASA science program is conducted on behalf of all the nation's scientists—remain timely and important. He observed that these principles were respected and effective during NASA's first 35 years but have been threatened, and even disavowed, during the past two decades. Fisk posed and answered two rhetorical questions, "Should we abandon our decadal process? Certainly not! Should we try and adapt the decadal process for today's reality? Absolutely!"

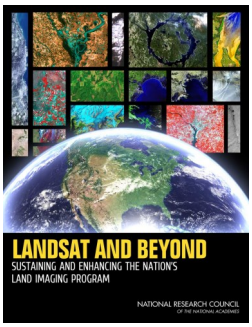
NASA PERSPECTIVE

John Grunsfeld offered a NASA perspective on decadal surveys by noting some of the challenges that confront the effort. A major question is, How do the surveys help NASA to navigate an uncertain future and engage the interest and support of the general public in the process? Surveys need to take some risks. Furthermore, we need to recognize that there will be serendipitous discoveries that survey committees cannot anticipate as well as unexpected budgetary and policy developments that can override the surveys. Grunsfeld emphasized that surveys must do much more than just present science priorities; they must provide a compelling science narrative that communicates the importance and value of the science.

Grunsfeld concluded his discussion by providing a set of questions for the workshop to address:

- Who are the primary users of surveys, and what is the full list of stakeholders?
- What can surveys do to aid NASA in supporting a vital program in the future?
- What can surveys do to help implement a balanced program over a decade and provide NASA with needed flexibility?
- How much should surveys do to help address priorities *across* disciplines as well as within disciplines?
- How can surveys integrate systems science across topical themes?
- How can surveys more fully integrate science across human spaceflight?
- How can surveys foster innovation so as to match scientific needs with new technologies?
- How can surveys engage new partners, and how can surveys improve coordination of planning in other countries?

To offer a broader context for the workshop's consideration of decadal surveys for space and Earth science, Grunsfeld emphasized that science is important for the nation and the world. Thus, the surveys are needed to help lay a foundation for a bright future.



Landsat and Beyond: Sustaining and Enhancing the Nation's Land Imaging

The Department of the Interior's (DOI's) U.S. Geological Survey (USGS) requested that the NRC's Committee on Implementation of a Sustained Land Imaging Program review the needs and opportunities necessary for the development of a national space-based operational land imaging capability. The committee was specifically tasked with several objectives including identifying stakeholders and their data needs and providing recommendations to facilitate the transition from NASA's research-based series of satellites to a sustained USGS land imaging program. Authors include the Committee on Implementation of a Sustained Land Imaging Program and staff members; Abigail Sheffer, Associate Program Officer, and Arthur Charo, Senior Program Officer .of the Space Studies Board; Division on Engineering and Physical Sciences. *Other staff are listed in the report*.

SUMMARY

Beginning with the 1972 NASA launch of the Earth Resources Technology Satellite (ERTS), later renamed Landsat 1, and continuing with the February 2013 launch of Landsat 8, the United States has amassed a sustained 40-year record of land remote sensing data acquired by satellites. Despite the transformational value of the data for diverse applications—including agriculture, forestry, hydrology, urbanization, homeland security, disaster mitigation, and climate change—the availability of these critical data for planning our nation's future is at risk.

The Department of the Interior's (DOI's) U.S. Geological Survey (USGS) tasked the National Research Council's (NRC's) Committee on Implementation of a Sustained Land Imaging Program to assess the needs and opportunities to develop a national space-based operational land imaging capability. The committee was asked to identify stakeholders and their data needs, recommend characteristics and critical program support areas expected of a sustained land imaging program, suggest critical baseline products and services derived from land imaging, and provide recommendations to facilitate the transition from NASA's research-based series of satellites to a sustained USGS land imaging program.

The committee met with stakeholders, including the DOI, NASA, the Office of Science and Technology Policy, the National Oceanic and Atmospheric Administration, the U.S Department of Agriculture, the Forest Service, commercial data providers, and multiple land imaging data users, and analyzed earlier reports on the uses and value of moderate-resolution multispectral data.

In this report, the committee recommends that a systematic and deliberate program, aimed at continuing to collect vital data within lower, well-defined, manageable budgets, replace the historical pattern of chaotic programmatic support and ad hoc design and implementation of spacecraft and sensors in the Landsat series. The committee concurred with former NASA Administrator James Fletcher's perspective and provided recommendations for the robust land imaging program he envisioned, albeit nearly 40 years later:

> If I had to pick one spacecraft, one Space Age development to save the world I would pick ERTS and the satellites which I believe will be evolved from it later in this decade.
>
> James C. Fletcher, NASA Administrator, 1975

IMPERATIVE FOR A SUSTAINED AND ENHANCED LAND IMAGING PROGRAM

Landsat 8, launched on February 11, 2013, has a 5-year design life, 10 years of fuel, and no assured successor. A successor mission has been under discussion in the U.S. executive and congressional branches, but their deliberations have not yet been made public. Moreover, the potential sharing of responsibilities with commercial and foreign contributors has not been articulated. The cost for Landsat 8 runs to approximately $1 billion. Although a budget to start planning the next Landsat mission has been provided to NASA in the fiscal year 2014 budget request, replacing Landsat 8 with a mission of similar scope will not be possible within the currently planned budget, unless it is a mission with a reduced set of requirements. Several of the Landsat satellites have been justified, planned, and executed separately, and the 40-year record owes more to the remarkable survival of Landsat 5 for two decades beyond its design life than to careful planning. Given this history and uncertainties about the future of the Landsat series of satellites, the committee, as a result of its activities over the course of the study, arrived at the following findings:

- The United States pioneered global, synoptic, frequent-repeat global imaging. Other nations are now developing systems whose capability rivals or exceeds that of U.S. systems. National needs require the United States to reassert leadership and maintain and expand capabilities.
- Space-based land imaging is essential to U.S. national security as it is a critical resource for ensuring our food, energy, health, environmental, and economic interests.
- The economic and scientific benefits to the United States of Landsat imagery far exceed the investment in the system.

Continued

- To best serve the needs of the United States, the land imaging program of the future requires an overarching national strategy and long-term commitment, including clearly defined program requirements, management responsibilities, and funding.
- The continuity of Landsat imagery has never been ensured through the development of a sustained government program. Instead, responsibility has been shifted from one organization to another over Landsat's 40-year history, resulting in persistent uncertainty for the future of this important asset.
- NASA has demonstrated that it is the civil agency with the technical capacity and the congressional support to design and build civilian space missions.
- The USGS-operated data management and distribution systems function effectively and efficiently.
- Building a satellite sequence with new requirements and technologies for each individual instrument is an expensive way to acquire land imaging data and inhibits the addition of new capabilities.
- *A sustained land imaging program will not be viable under the current mission development and management practices.*

The committee's primary recommendation is that the U.S. government should establish a Sustained and Enhanced Land Imaging Program with persistent funding to respond to current and future national needs. Such a program would

- **Develop a plan for a comprehensive, integrated program that capitalizes on the strengths of USGS and NASA, maintains current capability and the existing archive, and enhances the program as technology enables new imaging capabilities and data products;**
- **Ensure acquisition of land imaging data continuously from orbital platforms and, periodically, from airborne platforms, to respond to the needs of producers and consumers of derived data products along with users who analyze imagery;**
- **Establish partnerships with commercial firms and international land imaging programs to leverage enhanced capabilities;**
- **Coordinate land imaging data buys across the U.S. government; and**
- **Include a research and development component to improve data products based on core measurements and to develop new measurement methods and consider evolving requirements.**

For the Sustained and Enhanced Land Imaging Program to be successful, program responsibilities should be divided between USGS and NASA such that the agency responsible for balancing science requirements with mission complexity and cost is also provided with the necessary budget. Both agencies should participate in an iterative process to design missions that meet the needs of research and operational communities, but final decisions should be made by the agency that has been given the budget.

The committee recommends key elements of a successful sustained and enhanced land imaging program (SELIP) no matter where the federal government decides it should reside.

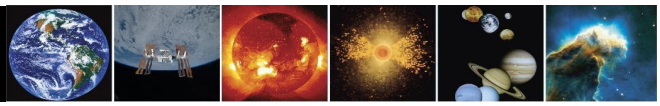
TECHNICAL CHARACTERISTICS OF THE CORE PROGRAM

SELIP would provide a core set of capabilities and measurements that continue to support operations and scientific investigations and maintain and enhance continuity with the information available since 1972. Landsat has provided an unequaled record of moderate-resolution (30-100 m) multispectral measurements of Earth's surface, the long-term continuity of which is critical for quantifying ecological, environmental, and land-use change. Preserving program continuity requires a satellite system and launch schedule that provides a continuous stream of land images and data and at the same time implicitly requires strategies to contend with future instrument or launch failures. Risk mitigation strategies could range from instruments ready to launch to securing agreements with international partners for data access. A "hot spare" on orbit or available for quick launch—as weather satellites have been managed historically—is not required. The core scientific and operational requirement for the SELIP is the capture and distribution of global, moderate-resolution, multispectral data calibrated sufficiently to allow the rigorous comparison of future image products with previous collections, easily accessible by all users, and free. Ensuring continuity of the ongoing data stream does not require continuing to fly the same sensor, nor does it require that all measurements be made from a single space platform. The section "Findings," in Chapter 2, presents a detailed list of user requirements. These include spatial resolution no coarser than 30 m, except in the thermal band; spectral coverage from the visible through the thermal infrared; and temporal coverage at 7- to 10-day frequency.

The top priorities for the Sustained and Enhanced Land Imaging Program (SELIP) should be to ensure that the core program provides for continuity of Landsat products and coverage on a secure and sustainable path.

The SELIP should take advantage of technological innovation in sensors, spacecraft, and data management and analysis to improve system performance, allow for new analyses that better exploit the data, and meet future needs. Because future measurements will derive from both current and new technologies, new implementations of existing data products derived from a multispectral sensor should be cross-calibrateable with Landsat legacy products and be essentially interchangeable for scientific and operational purposes.

Continued



To better meet these primary goals, the committee recommends that the program should:

- **Systematically monitor users and uses of Landsat data so that the program can evolve with changing user requirements.**
- **Consider alternative implementations that continue to enable the collection of global, moderate-resolution data with the full range of spectral capabilities.**

ENHANCING A SUSTAINED LAND IMAGING PROGRAM

Landsat has been the cornerstone of U.S. land imaging, but it has never comprised the totality of that effort. Although the core program of SELIP is a set of measurements and data products that preserve the continuity of the current record, the program can benefit from, and future users may require, the inclusion of data from other technologies. SELIP could benefit from defining land imaging more broadly, recognizing the increasing contributions from a diverse set of U.S. government, private sector, and international airborne and space-borne assets. The value added by increasing the synergistic use of these data is sufficient to consider broadening the scope of SELIP's data holding, while retaining the focus on Landsat-type measurements to continue the historical legacy. Some incorporation of other types of data requires only better coordination across the government by increased sharing of existing or planned data.

The committee recommends that the Sustained and Enhanced Land Imaging Program integrate measurements from commercial partners, space-borne sensors recommended by the 2007 NRC report *Earth Science and Applications from Space*, and a variety of airborne sensors and acquisitions to enable analyses not possible using only moderate-resolution multispectral data. These measurements should include, but not be restricted to, the following

- **Airborne and space-borne fine-resolution remote sensing data from public and commercial sources that can be used for detailed land use and land cover, urban infrastructure, transportation, hydrology, and disaster response;**
- **LiDAR data that can be used to extract precise digital surface and terrain models, building and vegetation height information, and vegetation canopy and its internal structure information;**
- **Synthetic aperture radar (SAR) and interferometric SAR (InSAR) images at resolutions suitable for studies of deformation, elevations, and surface cover; and**
- **Hyperspectral data collection and information extraction capabilities for hydrology, ecosystem health and biodiversity, and soil science and mineralogy.**

DATA SYSTEMS

The decision in 2008 to allow Landsat images to be downloaded free of charge greatly expanded the use of Landsat data and set a standard for international cooperation. There are now more downloads in 1 day than there were sales in an entire year when Landsat data were sold. USGS websites effectively provide access to imagery and derived products, with varying degrees of ease of use. Moreover, several commercial companies—for example, the Earth Sciences Resources Institute (ESRI), Google, Microsoft, and Yahoo—also provide high-resolution aerial and space-borne images, Landsat imagery, and products based on imagery Although these sites and services offer innovative ways to search for, display, and provide images and derivative products, they lack the comprehensive access to land imaging archives that are best offered to the public from an authoritative federal government source.

USGS, as part of the Sustained and Enhanced Land Imaging Program, should continue to deliver derived products from imagery without explicit cost to the end users.

USGS should

- **Improve search capabilities and transparency to users and**
- **Continue to interface with the private sector to improve access to public- and private-domain land imaging data products and services.**

The Sustained and Enhanced Land Imaging Program should develop a systematic process for identifying and prioritizing a wider suite of products, including essential climate variables, that can be derived from moderate-resolution land imagery, and for documenting and validating algorithms, including their modifications or replacements. In doing so, the program should

- **Define criteria that government-provided authoritative data sets should meet, among them such attributes as calibration, accuracy assessment, and validation, and including ground truth;**
- **Define criteria for which products should be provided by the government and which by the private sector;**
- **Implement procedures for development, cost estimation, peer review, and publication of algorithms that produce derived products; and**
- **Implement plans, procedures, and budgets for ongoing validation.**

Continued

Continued from page 10

OPPORTUNITIES ON THE PATH FORWARD

A sustained land imaging program will not be viable with current mission development and management practices. However, following the launch of Landsat 8 on February 11, 2013, there are several options for a sustainable land imaging program of core requirements that

also allow for enhanced capabilities and data products. Important opportunities include ensuring stable funding, programmatic improvements, and less cumbersome contracting processes.

The Sustained and Enhanced Land Imaging Program should create an ambitious plan to incorporate opportunities to improve land imaging capabilities while at the same time increasing operational efficiency and reducing overall program cost.

The program should consider a combination of the following to increase capabilities while reducing the costs for land imaging beyond Landsat 8:

- **Shift the acquisition paradigm by means of block buys and fixed-price contracting and by collaborating with commercial and international partners.**
- **Streamline the process by which satellites and sensors are designed, built, and launched, using a single organizational unit approach (a collaborative team approach) consisting of both government employees and contractors working together as a fully integrated team.**
- **Identify foreign sources of land imaging data that complement the U.S. core land imaging requirements and seek formal data-sharing agreements with them.**
- **Consider technological innovations, such as increasing the swath width and employing constellations of small satellites.**
- **Incrementally incorporate new technologies that leverage industry, international, and other technology development activities but do not compromise core operational capabilities.**
- **Accommodate candidates for improved or new instruments on a small satellite for the purpose of demonstrating new technologies.**
- **Take advantage of opportunities to fly as a secondary payload or as a shared ride.**

(Photo Credit: D. Day)

Antares Launch

On Wednesday, September 18, staff from the SSB and ASEB went up to the Keck building's tenth floor balcony and looked to the southeast, in the direction of the U.S. Capitol building. There they observed a small smoke trail, resulting from the launch of an Orbital Sciences Antares rocket over 100 miles away at Wallops Island. (The Antares launch looked much more dramatic from close up.) The Antares was carrying cargo to the International Space Station inside its Cygnus spacecraft as part of NASA's Commercial Orbital Transportation Services program. After matching up orbits with the ISS, a minor glitch and the need to dock another spacecraft at ISS resulted in a delay. Cygnus was finally docked with the ISS on September 30 and the astronauts began unloading cargo a day later.

(Photo credit: NASA)

STAFF NEWS

Meg Knemeyer has joined our team as our new Financial Officer starting on October 7th. Meg will work with Christina Shipman (who continues to work part time for the board as she phases into retirement over the next few months). Meg is a seasoned financial officer at the NRC, and we are lucky to have her join us. She brings an extant knowledge of the systems we use to do our financial tracking.

Anesia Wilks joins us as a program assistant this fall. Anesia brings experience working in the National Academies conference management office as well as other administrative positions in the DC metropolitan area. She will be working on the Framework for Analyzing the Needs for Continuity of NASA Sustained Remote Sensing Observations from Space Committee and the Committee on Solar and Space Physics. Anesia has a BA in psychology, Magna Cum Laude, from Trinity University in Washington, DC.

Christine Mirzayan Science and Technology Policy Graduate Fellowship Program

Over the years, the SSB has participated in the Christine Mirzayan Science and Technology Policy Graduate Fellowship Program. The program will be accepting applications for the January 2014 fellowship session soon. The application deadline was September 5, 2013. Selections will be made in late October 2013. More information can be found at <http://sites.nationalacademies.org/PGA/policyfellows/index.htm>.

Lloyd V. Berkner Space Policy Internship

In September, interns Jinni Meehan and Sierra Smith joined the SSB's Lloyd V. Berkner Space Policy Internship for a 12 week session. Jinni Meehan is a Ph.D. student at Utah State University in the department of physics. Her research is directed toward alleviating space weather effects on the Global Navigation Satellite System (GNSS) by better characterizing the ionosphere, which can improve forecast models. Sierra Smith recently graduated from James Madison University with an MA in history. The research for her master's thesis focused on the sociopolitical context of the search for extraterrestrial Intelligence and its broader relationship to space sciences.

Applications for the program's summer-2014 session are being accepted between September 1, 2013, and February 7, 2014. Selections will be made no later than March 7. Details concerning the program can be found at <http://sites.nationalacademies.org/SSB/ssb_052239>.

Frederick Harrison Dreves *completed his assignment as a 2013 summer intern. His reflections on his experience with the SSB appear below.*

My summer was wonderful. As a Lloyd V. Berkner Space Policy Intern, my work with the Space Studies Board exposed me to a wide range of new experiences. Within two days of arriving, I found myself in a House committee chamber, taking notes on a proposed nation-wide reorganization of STEM education. As the summer progressed, I attended space policy colloquiums, NASA advisory meetings, NRC committee meetings, and many other events. My trip to the Johnson Spaceflight Center in Texas was a personal highlight. Not only did I sit in Gene Kranz's chair at mission control, and attend serious discussions with the center director, but I ate real astronaut food! Check that one off the bucket list.

My work in the SSB office was equally diverse. I wrote policy summaries, researched legislation, and read community input for a study on human spaceflight at NASA. I put my communication skills to work, designing a report cover and writing a popular summary of the space and solar physics decadal survey.

Best of all were the people. The SSB program officers were always willing to share their wealth of knowledge and the admin staff moved mountains with a friendly laugh. I talked with professors of astrophysics, astronauts, NASA administrators, and aerospace engineers. I also met unpaid interns, food service workers, and grad students. Each of these individuals contributed in their own way to the gradual human pursuit of discovery and progress. At the Space Studies Board, I gained a better understand of this human pursuit -– including lessons of success and failure – and made a few small contributions of my own.

Summer intern Frederick Harrison Dreves (far left) with staff and members of the Committee on Human Spaceflight at a site visit of the Johnson Space Center in June 2013. (Photo credit: D. Day)

CONGRESSIONAL HEARINGS OF INTEREST

The following is provided for information only, as there was no space science related testimony provided on behalf of the National Research Council.

NASA Infrastructure: Enabling Discovery and Ensuring Capability
Subcommittee on Space Hearing | Sep 20, 2013 9:30am
<http://science.house.gov/hearing/subcommittee-space-hearing-nasa-infrastructure-enabling-discovery-and-ensuring-capability>

Dysfunction in Management of Weather and Climate Satellites
Subcommittee on Oversight and Subcommittee on Environment Joint Hearing | Sep 19, 2013 10:00am
<http://science.house.gov/hearing/subcommittee-oversight-and-subcommittee-environment-joint-hearing-dysfunction-management>

Nomination Hearing for Dr. Kathryn Sullivan
to be Under Secretary for Oceans and Atmosphere, Department of Commerce, and Administrator of the National Oceanic and Atmospheric Administration | Sep 19 2013
<http://www.commerce.senate.gov/public/index.cfm?p=Hearings&ContentRecord_id=ae9277dc-bb85-43ea-bf87-656f77084c54&Statement_id=727d60d0-5a51-483b-bdc3-bad6cbcf5101&ContentType_id=14f995b9-dfa5-407a-9d35-56cc7152a7ed&Group_id=b06c39af-e033-4cba-9221-de668ca1978a&MonthDisplay=9&YearDisplay=2013>

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Associate Program Officer	Lloyd V. Berkner Space Policy Intern
	* Staff of other NRC boards who are shared with the SSB.

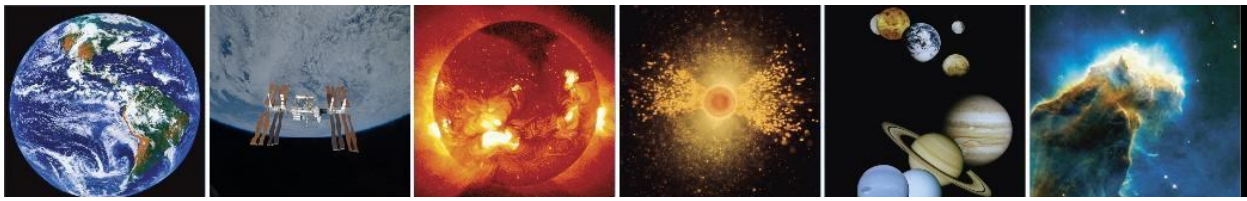
News from the National Academies

New National Academy of Engineering President Mote

NAE's new president C.D. (Dan) Mote Jr. began his term on July 1. Elected to a 6-year term Dr. Mote is the Regents Professor and Glenn L. Martin Institute Professor of Engineering in the A. James Clark School of Engineering at the University of Maryland (UMD) and past president of UMD. Mote, a mechanical engineer, was elected to NAE membership in 1988, served as an NAE councillor from 2002 to 2008, and has been NAE treasurer since July 2009. His science policy work includes membership on the committee that authored the National Academies' *Rising above the Gathering Storm*; chairing the committee on Global Science and Technology Strategies and Their Effect on the US National Security, which published the report *S&T Strategies of Six Countries*; and co chairing the committee on Science, Technology, Engineering, and Mathematics Workforce Needs for the US Department of Defense and the US Defense Industrial Base, which published the report *Assuring the US Department of Defense a Strong Science, Technology, Engineering, and Mathematics (STEM) Workforce*. He has received many awards and honors, including the 2005 NAE Founders Award. Mote succeeds Charles M. Vest, who completed a 6-year term as NAE president. Learn more at :<http://nas.edu/president/index.html>.

Christine Mirzayan Science & Technology Policy Graduate Fellowship Program Revived

Next spring will see the return of the Christine Mirzayan Science & Technology Policy Graduate Fellowship Program, which is now in its 16th year, The program provides early career individuals with the opportunity to spend 12 weeks at the National Academies in Washington, DC, learning about science and technology policy and the role that scientists and engineers play in advising the nation
Learn more at: <http://sites.nationalacademies.org/PGA/policyfellows/index.htm>



SSB Calendar

October

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October 4	Committee on Human Spaceflight: Public Stakeholder Opinions Panel	Washington, DC
October 15-16	Committee on Human Spaceflight: Technical Panel	Washington, DC
October 21-23	Committee on Human Spaceflight	Washington, DC
October 29-30	Committee on Earth Science and Applications From Space	Washington, DC
October 31-Nov. 1	Committee on Solar and Space Physics	Washington, DC
November 4-5	Committee on Astronomy and Astrophysics	Washington, DC
November 7-8	Space Studies Board Fall Meeting	Washington, DC
November 12-14	Committee on A Framework for Analyzing the Needs for Continuity of NASA-Sustained Remote Sensing Observations of the Earth from Space	Washington, DC
December 12	Committee on Human Spaceflight: Public and Stakeholders Opinions Panel	Washington, DC
January 13-15	Committee on Human Spaceflight	Irvine, CA

Future Meetings

March 3-5, 2014 NRC's Space Science Week

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

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

Our meeting facilities

National Academy of Sciences Building
2101 Constitution Ave NW
Washington, DC

Keck Center of the National Academies
500 Fifth St NW,
Washington, DC

Arnold and Mabel Beckman Center of the National Academies
100 Academy Drive
Irvine, CA

J. Erik Jonsson Conference Center
314 Quissett Ave
Woods Hole, MA

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Book and CD

- ☐ **Lessons Learned in Decadal Planning in Space Sciences; Summary of a Workshop (2013)** Book and CD
- ☐ **Landsat and Beyond: Sustaining and Enhancing the Nations Land Imaging Program (2013)** (Pre-Order)
- ☐ **Space Studies Board Annual Report 2012 (2013)** Book and CD
- ☐ **The Space Studies Board 1958-2012: Compilation of Reports (2013)** DVD
- ☐ **NASA's Strategic Direction and the Need for a National Consensus (2012)**
- ☐ **The Effects of Solar Variability on Earth's Climate: A Workshop Report (2012)**
- ☐ **Vision an Voyages for Planetary Science (2012) Booklet**
- ☐ **Solar and Space Physics: A Science for a Technological Society (2012)** Book and CD
- ☐ **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)** Book and CD
- ☐ **Assessment of Planetary Protection Requirements for Spacecraft Missions to Icy Solar System Bodies (2012)**
- ☐ **Assessment of a Plan for U.S. Participation in Euclid** CD Only
- ☐ **Technical Evaluation of the NASA Model for Cancer Risk to Astronauts Due to Space Radiation**
- ☐ **Report of the Panel on Implementing Recommendations from the New Worlds, New Horizons Decadal Survey (2012)**
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