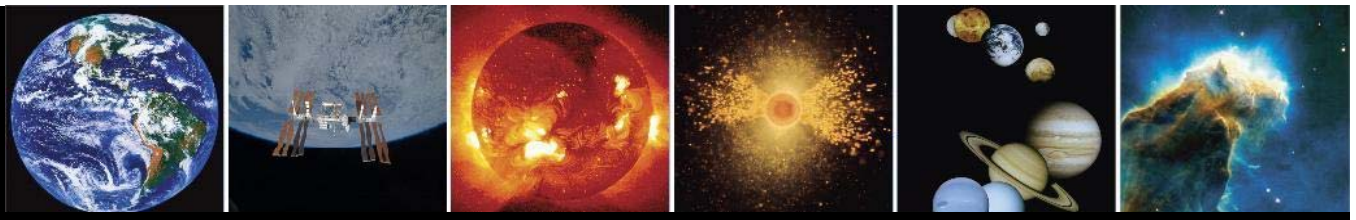
SPACE STUDIES BOARD NEWS



OCTOBER—DECEMBER 2012

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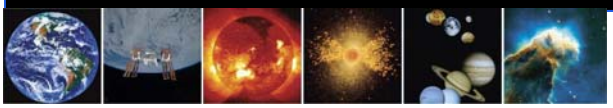
SSB Chair Charles F. Kennel and SSB Member Alan Dressler

We are deeply saddened to learn of the recent passing of board member **Robert P. Lin**, University of California, Berkeley. In addition to his active participation in many board activities, Dr. Lin also served as the U.S. representative to and vice president of, COSPAR. Our condolences to his family and friends.

OCTOBER—DECEMBER 2012

SPACE STUDIES BOARD NEWS



FROM THE CHAIR

This quarter's article is provided by the Co-Chairs of the Lessons Learned in Decadal Planning in Space Science Workshop Organizing Committee, SSB Chair Charlie Kennel and SSB Member Alan Dressler.

Between 2010 and 2012, the National Research Council completed four decadal surveys—in astronomy and astrophysics, planetary science, solar and space physics (heliophysics), and life and physical sciences in space. The SSB also completed a decadal midterm review on Earth sciences and applications from space. Taken together, these may comprise the most complete characterization of the state of the space sciences ever achieved. Yet, when the surveys arrived on NASA's doorstep, NASA found it difficult to implement recommendations that it anticipated it could when the surveys commenced their work.

What happened? How can we improve the next time around? These were the central questions motivating the "lessons learned" workshop convened by the SSB and Board on Physics and Astronomy on November 12-13, 2012. Some 150 participants from the domestic and international Earth and space science communities debated all aspects of the decadal review process: how the community reviews its past achievements; how it characterizes its present status and identifies future opportunities; how scientific ideas are shaped and reshaped by committee debate into "placeholder" mission and program concepts; how technical challenges are identified and conservative costs estimated; how cost and technical evaluations influence scientific choices and the committee process; how the survey committees interact with NASA and the scientific community during the study phase; what role international and interagency collaborations play in shaping recommendations; and above all, how to cope with policy fluctuations and budgetary uncertainty.

Uncertainty was the elephant in the room. It permeated all of the discussions at the workshop. The recent budgetary turmoil and a succession of continuing resolutions has given Congress little opportunity to express tangibly its goals for space science and exploration. There is pervasive uncertainty about the long-range direction of the federal funding for science, and this has discouraged policy initiative. Neither those who give advice nor those who receive it have a clear grasp of what the future holds, a reality for NASA that was underscored in the recently released report *NASA's Strategic Direction and the Need for a National Consensus* (NAP, 2012). The report, carried out under the auspices of the SSB's parent Division on Engineering and Physical Sciences but organized by SSB and ASEB staff, concluded that: "There is no national consensus on strategic goals and objectives for NASA. Absent such a consensus, NASA cannot reasonably be expected to develop enduring strategic priorities for the purpose of resource allocation and planning."

In such a circumstance—unprecedented in our experience—we were asking how we can shape our advice so that it preserves scientific value and remains resilient to budgetary instability. Can we craft "decision rules" that help NASA cope with downstream policy turbulence? How do we provide ongoing advice between decadals? What role do the SSB's standing committees, as stewards of the decadal surveys, play in that respect? Over the long history of the space program—until recently—the partnership between SSB and the NASA Advisory Council helped promote flexible NASA responses to the SSB's long-term advice. Can we rebuild the SSB's long and once productive working relationship with the NASA Advisory Council?

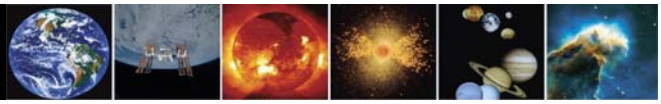
NRC reports are notable for their rigorous review; the most rigorous part of the review is to ensure that no report strays beyond its statement of task (SOT). As a result, nothing is more important to success than getting the SOT right. The SOT defines what issues shall be studied, how they shall be studied, and how they shall be described. The SOT negotiations between the NRC and NASA aim to develop a common understanding of terms of art that might otherwise be misinterpreted, including clear definitions that build understanding among the other stakeholders in the decadal surveys—OMB, OSTP, and Congress. There was a strong sense at the workshop that the next time around, the SSB ought to enlist broader community input before the SOT is set in stone. In the words of one participant: *"It's the statement of task, stupid!"*

Highlights of the presentations and discussions illustrate the breadth and depth of the program. The workshop began with a sober reflection by former SSB Chair and past NASA Associate Administrator (AA) Len Fisk, who pointed out that the principle that governed the conduct of the nation's space science program for the first 35 years of NASA was this: the National Research Council does the planning, and the NASA science program is conducted on behalf of the all of the nation's space scientists. However, during the past 20 years these principles have been challenged and at times disavowed. And throughout this past 20 years, the management structure by which NASA executes its science missions has been weakened.

The next session called upon past decadal survey chairs to reminisce about the surveys they led (what in corporate culture are called "war stories"); specifically, what worked—or did not work—well, and emphasizing the value of this unique activity that probes the collective will of an entire discipline community. An NRC staff presentation on the specific organization plans for recent decadals in Earth science and applications from space, astronomy and astrophysics, planetary science, and solar and space physics showed how their different scientific cultures necessitated tailored approaches to their surveys; for example, the "solar-system-target" program of planetary science, the "physical-process-and-system" focus in both heliophysics and Earth science, and the multicomponent program of astronomy and astrophysics with its myriad of cosmic 'residents' and phenomena. Given this variety, it is gratifying that the NRC's strategy for decadals works well for all.

The sessions on program formulation and the role of the cost assessment and technical evaluation (CATE) process delved into

(Continued on page 3)



the nuts-and-bolts of the decadal survey process. Attending discipline division directors (or their alternates) from within SMD floated the possibility of "science-only" prioritization; an approach they felt would be more robust to changing technical and budgetary realities throughout a decade. However, the scientists with experience in the prioritization process vigorously contended that the definition of representative missions capable of carrying out the science—even conceptual and immature—were essential in the exercise. These NASA representatives also argued that defining accurate cost estimates for pre-phase-A missions was not realistic and expressed the concern that the CATE process had taken on too much importance in the most recent round of decadals. The NASA officials contended that approximate "boxing" of notional missions into 'small, medium, and large' categories would be sufficient and probably better for program formulation. Despite lively discussions of the strengths and weaknesses of the CATE, including standards, feedback, and the role of iteration, workshop participants who were involved with recent surveys said that introducing *non-advocate* cost estimates into the process had been a success and should be retained in some form as an essential facet of all future surveys.

NASA management's seeming preference for "science-only" prioritization spurred discussion of the possibility of decoupling a decadal survey's science prioritization phase from the mission formulation phase; in effect, creating two separate processes—perhaps undertaken by different committees—as opposed to the traditional survey's integrated program-formulation process. This would be a substantial departure from current NRC practice and likely have significant ramifications on cost and schedule for both the decadal surveys themselves and the recommended programs.

The concluding sessions of the workshop covered, among other things, the question of whether high-profile missions such as James Webb Space Telescope and Mars Science Laboratory (the *Curiosity* rover) require special treatment by the decadal surveys and NASA—if this is even desirable, and how choices for such elevated status could be made across the disciplines. An important and thoughtful discussion of the increasingly important aspect of international collaboration highlighted some of the challenges in aligning and/or coordinating independent and rather different prioritization processes of the European Space Agency and the Japan Aerospace Exploration Agency. The attendees expressed admiration and satisfaction for the degree and quality of international collaboration on major space missions and the willingness of all involved to overcome the problems that international partnerships can encounter. Nevertheless, participants on the international panel posited that this is a major deficiency in the space science planning apparatuses currently in place.

In retrospect, the workshop could have gone on productively for another day. Participants were as engaged at the end as they were at the beginning and, throughout, earnest in the task. In fact, in our opinion each of the workshop's seven panels generated sufficient new ideas and suggestions to warrant exploration in the content of a follow-on study. Yet, beyond all the constructive suggestions, the most important thing was something we did *Not* hear: *The SSB should never do another decadal survey again.* We heard instead that decadals were unequivocally worth the effort, but that they could be made perhaps simpler and more resilient.

Although the workshop represents a first step in improving the decadal survey, it was a notable exercise in its own right for bringing together all of the stakeholders involved in this worthy effort and fostering interactions amongst groups and individuals who might not get the opportunity to talk to one another. We are all looking forward to the release of the workshop summary report this upcoming spring. ■

Board and Committee Member News

SSB member **Jim Anderson** of Harvard University received the Smithsonian American Ingenuity Award in physical science on November 28 in Washington, D.C. (see <http://www.smithsonianmag.com/science-nature/Smithsonian-American-Ingenuity-Awards.html#ixzz2HIjJ7300 >.

SSB ACTIVITIES

THE BOARD AND ITS STANDING COMMITTEES

The **Space Studies Board (SSB)** met November 14 at the Arnold and Mabel Beckman Center in Irvine, CA, following the Workshop on Lessons Learned in Decadal Planning in Space Science on November 12-13 (see below). The morning session focused on a discussion of the Board's impressions from the workshop and how the information that was gathered could be used in a potential follow-on study with recommendations for future decadal surveys and midterm assessments. The afternoon session was a discussion with the leadership of the Board's four standing committees on topics and issues that are of concern in their respective communities. The next full meeting of the Board will be held April 4-5, 2013, at the Keck Center in Washington, DC. Visit <http://www.nas.edu/ssb> to stay up to date on board, workshop, and study committee meetings and developments.

The 2012 workshop **Lessons Learned in Decadal Planning in Space Science** on November 12-13 in Irvine, CA, was hosted by the SSB in collaboration with the Board on Physics and Astronomy. This workshop reviewed and discussed key aspects of the most recent NRC 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 brought 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 also afforded an opportunity to discuss the recent mid-decade reviews. The workshop participants from government and the research community engaged in a dialog that identified ideas for the future evolution of the decadal survey and mid-decade review processes by examining closely how the recent surveys were executed and are being implemented. A report summarizing the discussions and dialog that took place at the workshop is being prepared and is expected to be released in Spring of 2013. More information on the workshop is available at <http://sites.nationalacademies.org/SSB/CurrentProjects/SSB_070954>.

The **Committee on Astronomy and Astrophysics (CAA)** held a WebEx meeting on October 16 to hear presentations on the final reports of the NASA Gravitational Wave Mission Concept Study from Tuck Stebbins (NASA) and the NASA X-ray Mission Concepts Study from Rob Petre (NASA). The CAA held another WebEx meeting on November 7 to hear about NASA Astrophysics' work on its Astrophysics Implementation Plan. CAA will meet again in March 2013 during NRC 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>.

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)

The **Committee on Earth Science and Applications from Space (CESAS)** held a teleconference with NASA Earth Science Director Mike Freilich on November 26 to discuss possible new activities for the committee. Planning has also begun for the committee's second in-person meeting in March 2013 as a part of the NRC Space Science Week. The committee plans to devote a day of discussion at the March meeting to the important issue of continuity in measurements and data. 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, did not meet during this quarter. CAPS held a committee conference call on November 26 where three topics were discussed. First, a status report was given by Co-Chair Philip Christensen on the CAPS presentations at the meetings of the SSB and the Planetary Science Subcommittee of the NASA Advisory Council. Second, a brief report was given by James Green on recent activities of NASA's Planetary Science Division. Third, the committee discussed possible topics for joint sessions with CAA during NRC Space Science Week. With respect to the third topic, CAPS is currently coordinating with the CAA to schedule a joint session on the topic of exoplanets. CAPS plans to hold another conference call in late January/early February. 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 NRC 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)** stood down while work was underway for the solar and space physics (heliophysics) decadal survey. Restart of the committee will occur in the next quarter with the first in-person meeting to occur on

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***

March 6-8, 2013, during the NRC Space Science Week. Appointments to the committee have been approved. More information about CSSP is available at <http://sites.nationalacademies.org/SSB/ssb_052324>.

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 CAPS standing committee.

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>. Since then, the report has briefed to senior officials at NASA Headquarters; NASA Goddard Space Flight Center; NSF; NOAA; the Johns Hopkins Applied Physics Laboratory; staff of OMB, OSTP, and the Senate Commerce Committee; the House Committee on Science, Space, and Technology; the Senate Appropriations Subcommittee on Commerce, Justice, Science, and Related Agencies; and the House Appropriations Subcommittee on Commerce, Justice, Science, and Related Agencies. A town hall event to discuss the survey was held on November 16 in Boulder, CO. In addition, the survey chair, Daniel N. Baker, testified on November 28 at a House Subcommittee on Space and Aeronautics hearing, "National Priorities for Solar and Space Physics Research and Applications for Space Weather Prediction." Dr. Baker also presented the findings of the survey at several events, including a town hall meeting, that occurred during the American Geophysical Union Fall meeting on December 3-7 in San Francisco, CA. NASA's initial response to the survey was also presented at this meeting <http://heliophysics.nasa.gov/AGU2012_Townhall.pdf> and <http://heliophysics.nasa.gov/HPRoadmapAGU_TownHall2012.pdf>. Detailed information about the survey is available at <http://sites.nationalacademies.org/SSB/CurrentProjects/SSB_056864>. A prepublication version of the report is available at <http://www.nap.edu/catalog.php?record_id=13060>; when completed in early 2013, the final version will also be posted to this site.

SSB workshop Lessons Learned in Decadal Planning in Space Science, November 12-13, 2012.

Space Studies Board meeting on November 14, 2012.

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 final version of ***The Effects of Solar Variability on Earth's Climate: A Workshop Report*** is now available at <http://www.nap.edu/catalog.php?record_id=13519>.

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

The study on **Human Spaceflight** is well underway, and the study committee has met twice. The first meeting took place in Washington, DC, on December 19. At this meeting, the committee discussed the study charge and key issues with congressional staff; the NASA Administrator, Deputy Administrator, and senior officials from the Human Exploration and Operations Mission Directorate

SSB ACTIVITIES, CONTINUED

and Science Mission Directorate; and individuals from the private sector with expertise regarding human spaceflight history, impacts, challenges, and opportunities. The participants in this first meeting also included about 85 members of the general public, both in person and remotely, and the agenda provided time for members of the public to address the study committee with their concerns or issues. The Human Spaceflight Committee subsequently met on January 8 at Stanford University in closed session to deliberate on the information received on December 19 and to consider future plans. At this meeting, the committee also discussed a preliminary list of technical and operational issues for further investigation by the Technical Feasibility Panel. This panel will examine these issues and others that may arise during the course of the study and provide feedback to the committee. The Technical Feasibility Panel has recently been appointed and will meet for the first time on February 4-5, 2013, in Washington, DC. The panel is chaired by committee member John Sommerer, Johns Hopkins University Applied Physics Laboratory.

The parent division of SSB and ASEB, the Division on Engineering and Physical Sciences (DEPS), was asked to conduct a comprehensive, agency-wide assessment of NASA's strategic direction. ASEB and SSB helped manage the **NASA's Strategic Direction** study for DEPS. The committee delivered its final report to NASA and Congress in early December. The committee chair, Albert Carnesale, and vice chair, Ron Sega, along with NRC staff, briefed Congressman Frank Wolf and his staff, NASA Administrator Charlie Bolden and Deputy Administrator Lori Garver, Director of the Office of Science and Technology and Assistant to the President for Science and Technology John P. Holdren, and staff of the Senate Appropriations and Authorizations Committees. Dr. Carnesale and NRC staff also briefed staff of the House Appropriations Committee and the House Science, Space, and Technology Committee as well as other congressional staff. On December 12, vice chair Ron Sega testified about the report before the House Science, Space, and Technology Committee. In addition to its five regular meetings, committee members 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 was printed in early January. The committee chair and vice chair may be requested to address future congressional hearings on the subject.

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 7). The inaugural COSPAR Symposium will be held in Bangkok, Thailand, on November 11-15, 2013. COSPAR business meetings will be held at COSPAR Headquarters in Paris, France, on March 18-21 , 2013.

In conjunction with the NRC's Division on Earth and Life Sciences, the SSB was represented at an exhibit booth at the **American Geophysical Union** Fall Conference in San Francisco, CA, on December 3-7. In addition, we exhibited at the 221st **American Astronomical Society** meeting in Long Beach, CA, on January 6-10, 2013, in partnership with the Board on Physics and Astronomy.

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.

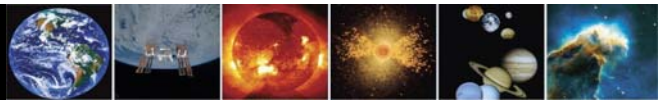
The SSB is now accepting applications from undergraduates for its summer 2013 program. The deadline for applications is February 1, 2013. Successful candidates will be contacted no later than March 1, 2013.

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 physical science or engineering (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 Office, 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.



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

Topics: Approximately 120 meetings covering the fields of COSPAR Scientific Commissions (SC) and Panels:

- SC A: The Earth's Surface, Meteorology and Climate
- SC B: The Earth-Moon System, Planets, and Small Bodies of the Solar System
- SC C: The Upper Atmospheres of the Earth and Planets Including Reference Atmospheres
- 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)
- Panel on Space Weather (PSW)
- Panel on Planetary Protection (PPP)
- Panel on Capacity Building (PCB)
- Panel on Education (PE)
- Panel on Exploration (PEX)
- Special events: Interdisciplinary lectures, round table, etc.

Selected papers published in *Advances in Space Research*, a fully refereed journal with no deadlines, open to all submissions in relevant fields.

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NEW RELEASE

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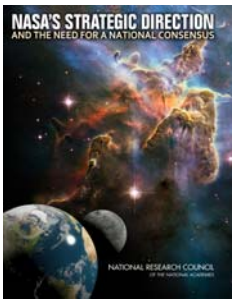
Copies of reports are available from the SSB office at 202-334-3477 or at <http://www.nap.edu/>.



NASA's Strategic Direction and the Need for a National Consensus

The report of the ad hoc Committee on NASA's Strategic Direction of the Division on Engineering and Physical Sciences was publically released on December 5, 2012, and is available at <http://www.nap.edu/catalog.php?record_id=18248>. The study was led by Chair Albert Carnesale, University of California, Los Angeles, and Vice Chair Ronald M. Sega, Colorado State University and Ohio State University, and staffed by Study Director Dwayne A. Day, Senior Program Officer Alan C. Angleman, Senior Program Officer David H. Smith, Editor Catherine A. Gruber, Research Associate Amanda R. Thibault, and Senior Program Assistant Linda Walker. Other staff are listed in the report.

Summary

The National Aeronautics and Space Administration (NASA) is at a transitional point in its history and is facing a set of circumstances that it has not faced in combination before. The agency's budget, although level-funded in constant-year dollars, is under considerable stress, servicing increasingly expensive missions and a large, aging infrastructure established at the height of the Apollo program. Other than the long-range goal of sending humans to Mars, there is no strong, compelling national vision for the human spaceflight program, which is arguably the centerpiece of NASA's spectrum of mission areas. The lack of national consensus on NASA's most publicly visible mission, along with out-year budget uncertainty, has resulted in the lack of strategic focus necessary for national agencies operating in today's budgetary reality. As a result, NASA's distribution of resources may be out of sync with what it can achieve relative to what it has been asked to do.

NASA now faces major challenges in nearly all of its primary endeavors—human spaceflight, Earth and space science, and aeronautics. While the agency has undertaken new efforts to procure commercial transportation to resupply the International Space Station (ISS) and has also initiated an effort to commercially procure crew transportation as well, the agency currently lacks a means of launching astronauts on a U.S. spacecraft to Earth orbit, where the agency operates the ISS, which was built at considerable time, effort, and expense.

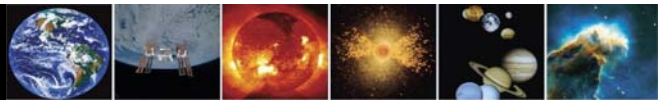
Although gaps in U.S. human spaceflight capability have existed in the past, several other factors, in combination, make this a unique period for NASA. These include a lack of consensus on the next steps in the development of human spaceflight, increasing financial pressures, an aging infrastructure, and the emergence of additional space-capable nations—some friendly, some potentially unfriendly. In addition, U.S. leadership in space science is being threatened by insufficient budgets to carry out the missions identified in the strategic plans (decadal surveys) of the science communities, rising cost of missions, decreasing science budgets, and the collapse of partnerships with the European Space Agency (ESA)—this at a time when others (most notably ESA and China) are mounting increasingly ambitious space programs. Finally, NASA's aeronautics budget has been reduced to the point where it is increasingly difficult for the agency to contribute to a field that U.S. industry and the national security establishment have long dominated.

These problems are not primarily of NASA's doing, but the agency could craft a better response to the uncertainty, for example, by developing a strategic plan that includes clear priorities and a transparent budget allocation process. A better response would improve NASA's ability to navigate future obstacles and uncertainties. An effective agency response is vital, because at a time when the strategic importance of space is rising and the capabilities of other spacefaring nations are increasing, U.S. leadership is faltering.

For the United States to be a leader in space, as required by the 1958 National Aeronautics and Space Act, it must be a country with bold ideas, science and engineering excellence, and the ability to convince others to work with it in the pursuit of common goals. Leadership depends on the perception of others that whoever is in the lead knows the way forward, is capable of forging the trail, and is determined to succeed despite inevitable setbacks. It does not mean dominance. Those who join are partners, not followers, and partnerships must be equitable, with all voices being heard.

Leadership is more nuanced today than during the Cold War rivalry with the Soviet Union over which country would achieve the next space "first." Countries that once depended on partnerships with the United States to execute their space programs now have other choices, including going it alone. If the United States is to continue to maintain international leadership in space, it must have a steady, bold, scientifically justifiable space program in which other countries want to participate, and, moreover, it must behave as a reliable partner.

Despite decades of U.S. leadership and technical accomplishment, many of these elements are missing today. Abrupt changes in the goals the United States is pursuing for human spaceflight, coupled with concerns about U.S. unreliability in key international partnerships, can erode this country's leadership position. The thrilling Mars Curiosity mission may be a testament to U.S. leadership in robotic space exploration today, but the sudden and dramatic proposed cut to the Mars exploration budget and withdrawal from the ExoMars program with Europe cast doubt on the future. Human spaceflight capabilities historically have served as a symbol of a country's leadership in space. This multi-year period when the United States cannot launch humans into space, requiring reliance on Russia for access to the ISS,



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further undermines any claim to leadership despite the programmatic success of the development of the ISS, which is, in fact, led by the United States.

THE COMMITTEE ON NASA'S STRATEGIC DIRECTION

In late 2011, the Congress directed NASA's Office of Inspector General to commission a "comprehensive independent assessment of NASA's strategic direction and agency management." Subsequently, NASA requested that the National Research Council (NRC) conduct this independent assessment. In the spring of 2012, the NRC Committee on NASA's Strategic Direction was formed and began work on its task.

The statement of task for this study appears in Appendix A (and is summarized in the Preface). Notably, the committee was *not* asked to deliberate on what should be NASA's goals, objectives, and strategy; rather, it was asked for recommendations on how these goals, objectives, and strategy might best be established and communicated.

HUMAN SPACEFLIGHT

The committee has seen little evidence that a current stated goal for NASA's human spaceflight program—namely, to visit an asteroid by 2025—has been widely accepted as a compelling destination by NASA's own workforce, by the nation as a whole, or by the international community. On the international front there appears to be continued enthusiasm for a mission to the Moon but not for an asteroid mission, although there is both U.S. and international interest in robotic missions to asteroids. This lack of national and international consensus on the asteroid-first mission scenario undermines NASA's ability to establish a comprehensive, consistent strategic direction that can guide program planning and budget allocation. While the committee did not undertake a technical assessment of the feasibility of an asteroid mission, it was informed by several briefers and sources that the current planned asteroid mission has significant shortcomings.

The asteroid mission is ostensibly the first step toward an eventual human mission to Mars. A human mission to Mars has been the ultimate goal of the U.S. human spaceflight program. This goal has been studied extensively by NASA and received rhetorical support from numerous U.S. presidents, and has been echoed by some international space officials, but it has never received sufficient funding to advance beyond the rhetoric stage. Such a mission would be very expensive and hazardous, which are the primary reasons that such a goal has not been actively pursued.

There also is no national consensus on what would constitute an appropriate mix of NASA's capability-driven and mission-driven programs. While a capabilities-driven approach may be the most reasonable approach given budget realities, such an approach still has to be informed by a clear, consistent, and constant path to the objective.

EARTH AND SPACE SCIENCE

NASA has clearly demonstrated the success of the strategic planning process for Earth and space science that is founded on the NRC's decadal surveys (NRC, 2007; a decadal survey on life and microgravity science [NRC, 2011a] has also been produced for the Human Exploration and Operations Mission Directorate). The decadal survey process has matured into a robust method for developing a set of goals and objectives for various programs that are based on a community consensus on an achievable suite of science programs in pursuit of high-priority, compelling science questions. However, even the best strategic plan is vulnerable to severe changes in the assumptions that underlie its development, whether those changes are applied internally or externally. As an example, the recent set of surveys on astronomy and astrophysics (NRC, 2010) and planetary science (NRC, 2011b) were based on budget projections provided to the relevant decadal committees, and now these projections exceed the current budget as well as current budget projections. Rising costs associated with increasingly complex missions, declining science budgets, international partnerships that fell apart, and mission cost overruns have strained science budgets to their breaking point. As a result, key decadal priorities in astrophysics, planetary science, and Earth science will not be pursued for many years, or not at all. The carefully crafted strategic planning process, with its priority setting and consensus building, which has led in the past to the United States leading the world with science missions such as the Curiosity rover on the surface of Mars and the Hubble Space Telescope, is now in jeopardy because it no longer may lead to a tangible program outcome.

AERONAUTICS

The NASA aeronautics program has made important contributions to national priorities related to the U.S. air transportation system, national defense, and those portions of the space program that include flight through Earth's atmosphere. However, the budget for NASA's aeronautics program shrank significantly in the 2000-2010 decade, and the full historically demonstrated potential of the aeronautics program is not being achieved given the current levels of funding. During the course of its deliberations, the committee did not hear a clear rationale for the overall decline in NASA aeronautics spending during the past 15 years.

TECHNOLOGY DEVELOPMENT

Because of the unique nature of most of its missions, NASA has had a number of very specific technological requirements in areas ranging from expendable and reusable launch vehicles to deep-space propulsion systems to radiation protection for astronauts, and much more. The recently established Space Technology Program has carried out a roadmapping and priority-setting strategic planning process for such technologies, assisted by the NRC, but the program is yet to be funded at the levels requested by the President's budget.

BUDGETS AND BALANCE

The funding for NASA's total budget has been remarkably level in constant-year dollars for more than a decade. However, there has been some instability at the programmatic level, and the out-year projections in the President's budget are unreliable, which makes it difficult for program managers to plan activities that require multi-year planning. Put another way, although the budget may have been level over time, NASA experienced substantial program instability over the same period. Numerous times the agency initiated new programs with the *expectation* that budgets would increase to support them (a basic requirement for optimizing any

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development program's budget), only to have no increases emerge. Taken in aggregate, this situation has been wasteful and inefficient. Even leaving aside the funding requirements for large procurements, it is tempting to assume that if NASA officials knew to expect a flat budget they could plan better, but in several recent cases they were told (even required) to expect funding that never ultimately emerged.

Last, flat budgets historically have not allowed NASA to pursue major initiatives in human spaceflight; see Figures 1.4 and 1.5, where the budget bumps for Apollo and the space shuttle/ISS programs are apparent.

NASA cannot execute a robust, balanced aeronautics and space program given the current budget constraints. For example, major components needed for future human exploration (including important life sciences experiments on the ISS) are not currently in the budget; high-priority science missions (including robotic planetary exploration missions that are precursors to human exploration) identified in the most recent NRC decadal survey are unfunded; and aeronautics now accounts for only about 3 percent of the total NASA budget. In addition, individual NASA centers are finding it necessary to selectively reduce their infrastructure or find alternative ways to support it (e.g., through external collaborations). External partnerships can be highly beneficial, especially in the current fiscally constrained environment, and may enable NASA to execute a robust and balanced aeronautics and space program without additional funds. However, coordination and integration of such activities for the overall benefit of NASA are both essential for success.

Because of legislative and regulatory limitations, NASA officials lack flexibility in how to manage the agency in terms of personnel and facilities, a factor contributing to the mismatch between budget and mission. With the current available-budget-driven approach, intermediate milestones and completion dates for some programs have been delayed. This in turn results in a lack of tangible near-term performance outcomes from cost-inefficient programs that by nature must accommodate increases in fixed and indirect costs. Delays also have a deleterious effect on mission performance; stretching programs out limits opportunities for NASA to develop and incorporate new technology into program architectures defined years before.

There is a significant mismatch between the programs to which NASA is committed and the budgets that have been provided or anticipated. The approach to and pace of a number of NASA's programs, projects, and activities will not be sustainable if the NASA budget remains flat, as currently projected. This mismatch needs to be addressed if NASA is to efficiently and effectively develop enduring strategic directions of any sort.

To reduce the mismatch between the overall size of its budget and NASA's current portfolio of missions, facilities, and personnel, the White House, Congress, and NASA, as appropriate, could use any or all of the following four (non-mutually exclusive) options. The committee does not recommend any one option or combination of options but presents these to illustrate the scope of decisions and tradeoffs that could be made. Regardless of the approach or approaches selected, eliminating the mismatch will be difficult.

- *Option 1.* Institute an aggressive restructuring program to reduce infrastructure and personnel costs to improve efficiency.
- *Option 2.* Engage in and commit for the long term to more cost-sharing partnerships with other U.S. government agencies, private sector industries, and international partners.
- *Option 3.* Increase the size of the NASA budget.
- *Option 4.* Reduce considerably the size and scope of elements of NASA's current program portfolio to better fit the current and anticipated budget profile. This would require reducing or eliminating one or more of NASA's current portfolio elements (human exploration, Earth and space science, aeronautics, and space technology) in favor of the remaining elements.

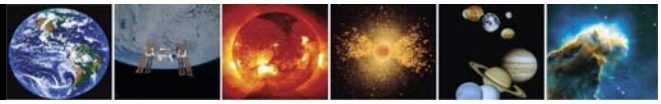
Each of the above sample options, with the possible exception of Option 2, would require legislative action. Every option except for Option 3 would require substantial changes within NASA in order to substantially address the mismatch between NASA's programs and budget. Before implementation of any such options, the advantages and disadvantages, including possible unintended consequences, would deserve careful consideration. For example, if not handled carefully, Option 1 could constrain future mission options or increase future mission costs if unique facilities needed by future missions were decommissioned. Option 1 might also diminish NASA's workforce capabilities if changes in policies prompt large numbers of key personnel to retire or seek other employment. To be effective, Option 2 might require congressional authorization for NASA to make long-term financial commitments to a particular program to assure prospective partners that neither NASA nor Congress would unilaterally cancel a joint program. Option 3, of course, is ideal from NASA's perspective, but its selection also seems unlikely given the current outlook for the federal budget. Option 4 is perhaps the least attractive, given the value of each major element in NASA's portfolio.

The committee has identified significant impacts of current budget constraints on the individual programs at NASA and has described the kinds of options that would have to be considered to address the mismatch between the scope of NASA's programs and budget. It has not attempted to judge the appropriateness of the budget distribution among these programs internal to the agency. Moreover, it would have been difficult to do so because of the absence of stated priorities that would provide a framework for making that assessment. In addition, the committee notes that it was not asked to set those kinds of agency-wide priorities.

The foregoing observations (and the detailed discussions in the body of this report) lead the committee to reach the following conclusions and offer the related recommendations:

Conclusion: There is no national consensus on strategic goals and objectives for NASA. Absent such a consensus, NASA cannot reasonably be expected to develop enduring strategic priorities for the purpose of resource allocation and planning.

Recommendation: The administration should take the lead in forging a new consensus on NASA's future that is stated in terms of a set of clearly defined strategic goals and objectives. This process should apply both within the administration and between the administration and Congress and should be reached only after meaningful technical consultations with potential international



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partners. The strategic goals and objectives should be ambitious, yet technically rational, and should focus on the long term.

Recommendation: Following the establishment of a new consensus on the agency's future, NASA should establish a new strategic plan that provides a framework for decisions on how the agency will pursue its strategic goals and objectives, allows for flexible and realistic implementation, clearly establishes agency-wide priorities to guide the allocation of resources within the agency budget, and presents a comprehensive picture that integrates the various fields of aeronautics and space activities.

Recommendation: NASA's new strategic plan, future budget proposals prepared by the administration, and future NASA authorization and appropriation acts passed by Congress should include actions that will eliminate the current mismatch between NASA's budget and its portfolio of programs, facilities, and staff, while establishing and maintaining a sustainable distribution of resources among human spaceflight, Earth and space science, and aeronautics, through some combination of the kinds of options identified above by the committee. The strategic plan should also address the rationale for resource allocation among the strategic goals in the plan.

Recommendation: NASA should work with other U.S. government agencies with responsibilities in aeronautics and space to more effectively and efficiently coordinate U.S. aeronautics and space activities.

Conclusion: The NASA field centers do not appear to be managed as an integrated resource to support the agency and its strategic goals and objectives.

Conclusion: Legislative and regulatory limitations on NASA's freedom to manage its workforce and infrastructure constrain the flexibility that a large organization needs to grow or shrink specific scientific, engineering, and technical areas in response to evolving goals and budget realities.

Although the committee carefully analyzed NASA's current strategic plan, as well as previous ones, it ultimately concluded that the strategic planning process is affected more by what happens outside the agency than by any process inside NASA. The lack of a national consensus on what NASA should do constrains NASA's ability to plan and to operate.

The committee recognizes that it lacked the capability and time to conduct a detailed supporting analysis and to make specific recommendations for changes in the current NASA infrastructure. However, the committee offers a path forward for NASA to follow, in close collaboration with the President and Congress.

Recommendation: With respect to NASA centers:

- The administration and Congress should adopt regulatory and legislative reforms that would enable NASA to improve the flexibility of the management of its centers.
- NASA should transform its network of field centers into an integrated system that supports its strategic plan and communications strategy and advances its strategic goals and objectives.

Today it is common to declare that all future human spaceflight or large-scale Earth and space science projects will be international. Many U.S. leaders also assume that the United States will take the lead in such projects. However, American leadership in international space cooperation requires meeting several conditions. First, the United States has to have a program that other countries want to participate in, and this is not always the case. Second, the United States has to be willing to give substantial responsibility to its partners. In the past, the approach of the United States to international partnership has too often been perceived as being based on a program conceived, planned, and directed by NASA. Third, other nations must be able to see something to gain—in other words, a reason to partner with the United States. Finally, the United States has to demonstrate its reliability and attractiveness as an international partner.

The capabilities and aspirations of other nations in space have changed dramatically since the early days of the space race between the Soviet Union and the United States. One of the most important successes of the ISS was its international character and the role of the United States as the managing partner in a global enterprise. If the United States does seek to pursue a human mission to Mars, such a mission will undoubtedly require the efforts and financial support of many nations.

Recommendation: The United States should explore opportunities to lead a more international approach to future large space efforts both in the human space program and in the science program.

In preparing this report, the committee held three meetings at which current and former NASA leaders, representatives of other government agencies, academics, and historians shared their views of the origin and evolution of NASA and its programs and the issues facing the agency today. The committee received input from nearly 800 members of the public through a Web-based questionnaire, and small groups of committee members visited each of the nine NASA field centers and the Jet Propulsion Laboratory. Furthermore, the committee reviewed a large number of studies conducted by the NRC and other groups over the decades that made recommendations about the conduct of NASA's programs and the agency's future, as well as NASA's strategic plans back to 1986.

The committee was impressed with the quality of personnel and the level of commitment of the agency's civil service and contractor staffs and the superb quality of the work done by the agency in general, most notably recently demonstrated by the Curiosity landing on Mars. But the committee also heard about frustration with the agency's current path and the limitations imposed on it by the inability of the national leadership to agree on a long-term direction for the agency. Only with a national consensus on the agency's future strategic direction, along the lines described in this report, can NASA continue to deliver the wonder, the knowledge, the national security and economic benefits, and the technology typified by its earlier history. ■

CONGRESSIONAL HEARINGS OF INTEREST

National Priorities for Solar and Space Physics Research and Applications for Space Weather Prediction

U.S. House of Representatives
Subcommittee on Space and Aeronautics Hearing
November 28, 2012

Hearing charter and testimony are available at <http://science.house.gov/legislation?type=hearing>

Witnesses: Daniel Baker, Director, Laboratory for Atmospheric and Space Physics and Professor, Astrophysical and Planetary Sciences, University of Colorado at Boulder; Chair, Decadal Survey in Solar and Space Physics, National Research Council; Charles J. Gay, Deputy Associate Administrator, Science Mission Directorate, National Aeronautics and Space Administration; Laura Furgione, Acting Assistant Administrator for Weather Services and Acting Director, National Weather Service, National Oceanic and Atmospheric Administration.

Statement of Daniel N. Baker
Broad Reach Endowed Chair of Space Sciences
Professor, Department of Physics and Department of Astrophysical and Planetary Sciences
Director, Laboratory for Atmospheric and Space Physics
University of Colorado, Boulder

Mr. Chairman, Ranking Minority member, and members of the Committee, I want to thank you for the opportunity to testify today at the hearing on "National Priorities for Solar and Space Physics Research and Applications for Space Weather Prediction." My name is Daniel Baker and I am a professor of astrophysical and planetary sciences at the University of Colorado. I am also the Director of the Laboratory for Atmospheric and Space Physics at CU-Boulder. The Laboratory is a research institute that has more than 60 teaching and research faculty in the several disciplines of space and Earth sciences. My institute, which we call LASP for short, receives some $60+ million per year to support experimental, theoretical, and data analysis programs in the Space and Earth Sciences. The majority of these resources come from NASA. But increasing support comes from NOAA, NSF, and other federal agencies. LASP presently supports some 130 engineers as well as dozens of highly skilled technicians and support personnel. We are very proud, as well, that LASP has nearly 70 graduate students and over 100 undergraduate students each year who are pursuing education and training goals in space science and engineering.

I myself am a space plasma physicist and I have served as a principal investigator on several scientific programs of NASA. I am now a lead investigator in the recently launched Radiation Belt Storm Probe (RBSP) mission that is part of NASA's Living With a Star program. I am also an investigator on NASA's Cluster, MESSENGER, and Magnetospheric Multi-Scale (MMS) missions. I recently served as Chair of the National Research Council's Committee on Solar and Space Physics and as a member of the NRC Space Studies Board. I am testifying today in my capacity as chair of the NRC Committee for a Decadal Strategy for Solar and Space Physics (Heliophysics), which recently published the report, *Solar and Space Physics: A Science for a Technological Society* (the "decadal survey"). The report is available online at: <http://www.nap.edu/catalog.php?record_id=13060>. Although my testimony follows the specific recommendations and supporting text in that report; the opinions I express should be attributed to me unless stated otherwise.

The charter for today's hearing includes 3 overarching questions:

1. What are the [decadal] survey committee's top recommendations for the coming decade? What is the current state of the solar and space physics programs at NASA and what are the prospects for the foreseeable future to follow the Decadal Survey's recommendations given that budgets will remain essentially flat?

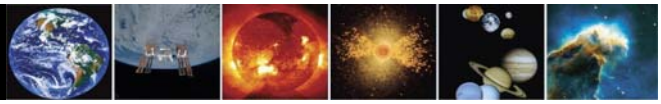
2. What is the role of the Space Weather Prediction Center at NOAA? To what extent does NOAA work with NASA to develop and disseminate space weather models and forecasts? Where can coordination between agencies improve?

3. The recent solar and space physics decadal survey concluded that "a national, multifaceted program of both observations and modeling is needed to transition research into operations more effectively." What steps is each agency taking to ensure a solar and space physics research program is effectively

Daniel Baker, Chair, Decadal Survey in Solar and Space Physics. Credit: House Committee on Science, Space and Technology.

Charles J. Gay, NASA. Credit: House Committee on Science, Space and Technology.

Laura Furgione, National Weather Service. Credit: House Committee on Science, Space and Technology.



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maintained and improved?

In my testimony below, I address these questions sequentially; following the testimony, I have appended the Summary of decadal survey report, which provides a more comprehensive review of the decadal survey's origins, organization, objectives, and recommendations.

Background and Overview of the 2013-2022 Decadal Survey in Solar and Space Physics

From the interior of the Sun, to the upper atmosphere and near-space environment of Earth, and outwards to a region far beyond Pluto where the Sun's influence wanes, advances during the past decade in space physics and solar physics have yielded spectacular insights into the phenomena that affect our home in space. The decadal survey report, requested by NASA and the National Science Foundation, and carried out with their financial support and with the cooperation of other federal agencies, especially NOAA, presents a prioritized program of basic and applied research for 2013-2022 that will advance scientific understanding of the Sun, Sun- Earth connections and the origins of "space weather," and the Sun's interactions with other bodies in the solar system. The report includes recommendations directed for action by the study sponsors and by other federal agencies—especially NOAA, which is responsible for the day-to-day ("operational") forecast of space weather. Appended to this testimony is the executive summary of the decadal survey, which provides details on all of the survey report's recommendations.

The present decadal survey is the second NRC decadal survey in solar and space physics. Like all NRC decadal survey reports, this decadal survey was conducted with the assistance of a broad swath of the solar and space physics community; the final report represented the efforts of more than 85 solar and space physicists and space system engineers working over an 18-month period. In developing its recommendations, the survey committee also drew on over 300 "white papers" that were submitted by the community in response to a broadly-distributed survey request for concepts and new ideas to advance the discipline. The survey committee also sponsored numerous town-hall meetings and workshops prior to the formal start of its deliberations.

Per the study statement of work, the survey's top-level tasks were to:

1. Provide an overview of solar and space physics science and provide a broad survey of the current state of knowledge in the field;
2. Identify the most compelling science challenges;
3. Identify the highest priority scientific targets for the interval 2013-2022; and
4. Develop an integrated research strategy.

Survey Recommendations

The survey report's recommendations are shown in the report summary that is appended to this testimony. The recommended actions include completion of projects in NASA and the National Science Foundation's (NSF's) current program, creation of a new "mid-scale" projects line at NSF, augmentation of NASA and NSF "enabling" programs, and acceleration and expansion of NASA's Heliophysics Explorer Program. For later in the decade, the report recommends beginning new moderate-size NASA missions to address high-priority science targets, and a multiagency initiative to address pressing needs for improved forecasts of space weather and predictions of its impacts on society.

A key element of the survey is that its recommended program was fit to resources anticipated in a challenging fiscal environment. To ensure that the costs of the recommended NASA program were realistic, the NRC contracted with the Aerospace Corporation, who conducted an independent cost and technical evaluation (CATE) of selected reference mission concepts. In addition, the survey committee provided "decision rules" that can be employed to maintain the vitality of the program should the recommended program need to be adjusted because of unanticipated technical problems, cost overruns, or budget shortfalls. At the request of NASA, decision rules specific to the flagship mission Solar Probe Plus were also provided.

Four scientific goals inform the survey committee's recommendations:

1. Establish the origins of the sun's activity and predict the variations of the space environment;
2. Determine the dynamics and coupling of Earth's magnetosphere, ionosphere, and atmosphere and their response to solar and terrestrial inputs;
3. Understand the interaction of the sun with the solar system and the interstellar medium; and
4. Discover and characterize fundamental processes that occur both within the heliosphere and throughout the universe.

Considering cost, schedule, and complexity, the decadal survey provides a number of research recommendations to reach these goals. It also considers challenges that could impede achievement of the recommended program, including budget issues, the necessity to coordinate activities across multiple agencies, and the limited availability of appropriately-sized and affordable space launch vehicles.

The report's first recommendation is to continue support for the key existing program elements that comprise the Heliophysics Systems Observatory and for successful implementation of programs in advanced stages of development. Second in priority is the establishment of a new, integrated multiagency initiative—"DRIVE"—that will more effectively exploit NASA and NSF scientific assets. Fully exploiting available resources is always a priority; in the highly constrained budgets anticipated in the foreseeable future, it is a necessity.

The DRIVE initiative has five components:

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

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researchers.

As shown in Figure 1, below, the survey committee recommends a gradual implementation of the elements of DRIVE (because of budget constraints); in addition, elements of DRIVE are sequenced to take advantage of the implementation of new programs later in the decade survey interval. For example, Mission Operations and Data Analysis (MO&DA) augmentation begins in 2016, at a time when the Solar Dynamics Observatory (SDO) will have moved out of its prime mission phase, thus adding greatly to data covered by the general Guest Investigator (GI) program. The NASA portion of DRIVE is fully implemented by 2022, amounting to an augmentation to existing program lines that is equivalent to approximately $33 million in current (2013) dollars. Note: In developing the DRIVE run-outs, the survey committee assumes a 2.7% rate of inflation, which is what NASA currently assumes as the inflation factor to be used for its new starts.

Third, the report recommends that NASA accelerate and expand the Heliophysics Explorer program, which provides frequent flight opportunities to enable the definition, development and implementation of mission concepts. Informing this recommendation was the recognition that the solar and space physics community has done much of its best and most innovative research with Explorers, a program which had been reduced during the previous decade. A key objective for the next survey interval—2013-2022— is to restore the number of Medium and Explorer class missions such that, in combination with competitively selected Instrument Opportunities on hosted payloads (MOOs), a higher cadence can be achieved that is capable of maintaining the vitality of the science disciplines. Augmenting the current program by $70 million per year, in fiscal year 2012 dollars, will restore the option of mid-size Explorers and allow them to be offered in alternation with small explorers every 2 to 3 years. As part of the augmented Explorer program, it is also recommended that NASA support regular selections of Missions of Opportunity, which 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.

A highly constrained budget and the need to complete missions already in advanced stages of development postpones any new moderate- or large-class starts until midway in the survey interval of 2013-2022. Figure 2, below, shows a proposed implementation of the core NASA program, in which each of the assets required to achieve the goals of the solar and space physics program are implemented at what is considered a proper cadence and within a budget profile that should be attainable. The recommended program addresses in a cost effective manner many of the most important and interesting science objectives, but the anticipated budget significantly constrains what can be accomplished. Built on top of the existing research foundation, the core program recommended here ensures that a proper distribution of resources is achieved. In particular, it restores a balance between small, medium, and large missions.

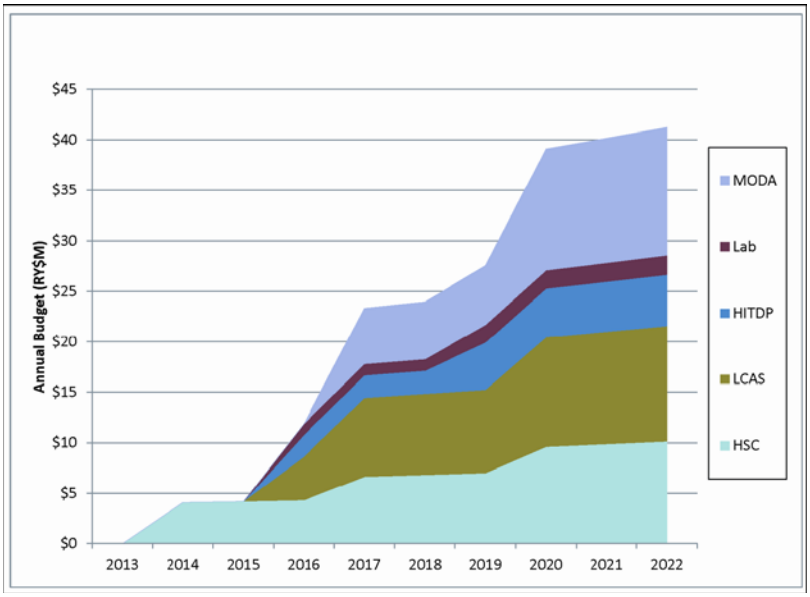

Figure 1: NASA DRIVE implementation: For the cost of a small mission, the DRIVE initiative recommends augmentations to NASA mission-enabling programs that have been carefully chosen to maximize the effectiveness of the program overall. Six of the DRIVE sub-recommendations have cost impact for NASA. Of these, *NASA Mission Guest Investigator* would require a cost allocation within STP and LWS missions of ~2% of total mission cost for a directed guest investigator program. The other five, *NASA LCAS Microsatellites (LCAS), MO&DA augmentation (MODA), Heliophysics Science Centers (HSCs), Heliophysics Instrument and Technology Development Program (HITDP), and Multi-agency Laboratory Experiments (Lab),* are shown in the figure.

As detailed in the survey report, 3 new moderate- and 1 large-class mission starts are recommended later in the decade to investigate space physics at the edge of heliosphere, where the sun's influence on interstellar space is no longer dominate; the effects of processes in Earth's lower atmosphere on conditions in space; fundamental questions related to the creation and transport of plasma in Earth's ionosphere and magnetosphere; and how the Earth responds globally to magnetic storms from the sun.

A key recommendation of the survey committee is 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 approximately $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. With larger-class LWS missions, which the committee recommends to continue to be Center-led, 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.

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Enabling Effective Space Weather and Climatology Capabilities

NASA research satellites, such as ACE, SOHO (with ESA), STEREO, and SDO, designed for scientific studies, provide critical measurements essential for specifying and forecasting the space environment system, including the outward propagation of eruptive solar events and solar wind conditions upstream from Earth. While these observational capabilities have become essential for space environment operations, climatological monitoring, and research, NASA currently has neither the mandate nor the budget to sustain these measurements into the future.

A growing literature has documented the need to provide a long-term strategy for monitoring in space, and elucidated the large number of space weather effects, the forecasting of which depend critically on the availability of suitable data streams.

A new plan is also needed that synthesizes and capitalizes on the strengths of the agencies participating in the NSWP as well as on opportunities in the commercial sector, such as the Active Magnetosphere and Planetary Electrodynamics Response Experiment (AMPERE) that uses the Iridium constellation of communications satellites to measure the electric currents that link Earth's atmosphere and space. The committee sees a need for a clearinghouse for coordinating the acquisition, processing, and archiving of underutilized real-time and near real-time ground- and space-based data needed for space weather applications. For example, highly valued energetic particle measurements made by GPS and LANL GEO satellites for specification of the radiation belts are not now routinely provided. Likewise, model development has been supported by individual agencies rather than being coordinated across relevant stakeholders. An example is the provision of measurements of particles and fields at the L1 Lagrange point (or, using technologies such as solar sails, closer to the Sun on the Sun-Earth line), which is critical for short term forecasting of harmful space weather effects such as radiation, GPS accuracy reduction, and potentially deleterious geomagnetically induced currents on the power grid. The decadal survey steering committee found that the existing ad hoc approach towards the provision of these capabilities was inadequate.

In the survey report, the committee articulates a vision for an enhanced national commitment by partnering agencies for continuous measurements of critical space environment parameters, analogous to the monitoring of the terrestrial environment NASA is conducting in collaboration with a number of other agencies, for

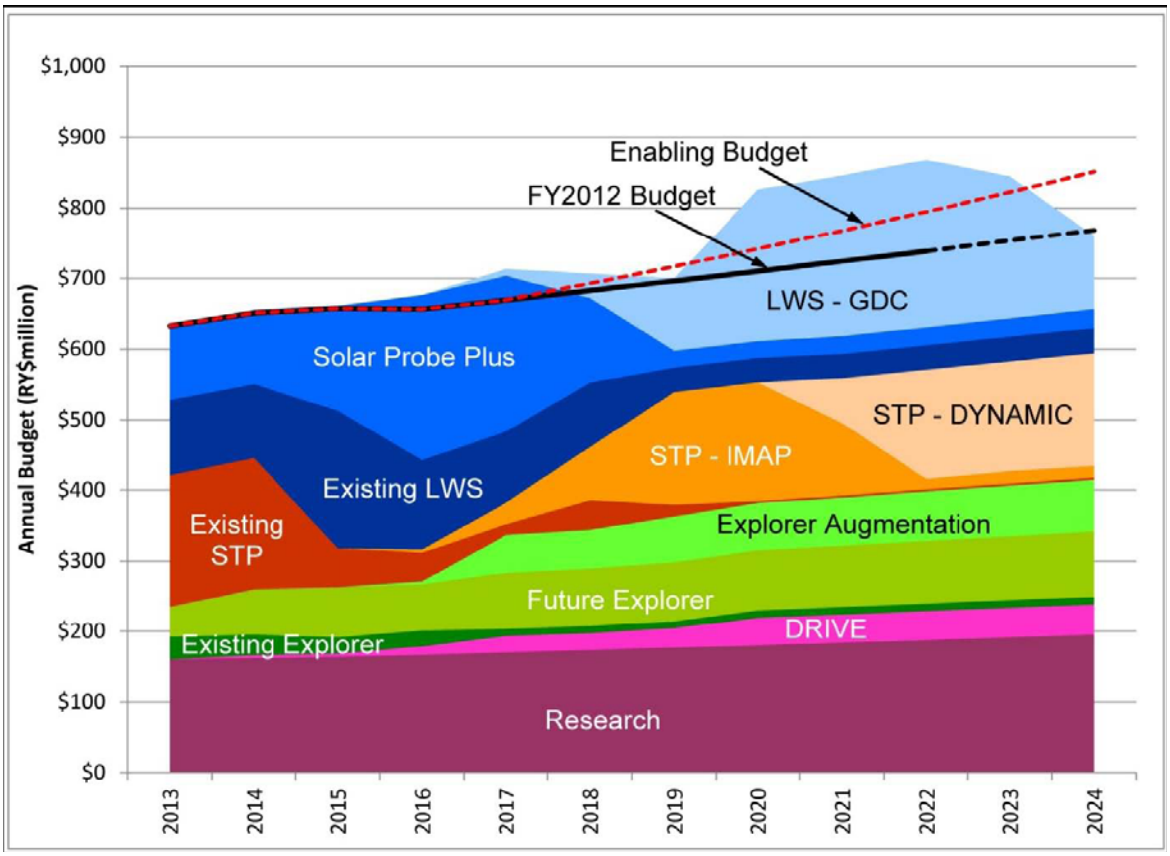


Figure 2: Heliophysics budget and program plan by year and category from 2013 to 2024. The solid black line indicates the funding level from 2013 to 2022 provided to the committee by NASA as the baseline for budget planning, and the dashed black line extrapolates the budget forward to 2024. After 2017 the amount increases with a nominal 2 percent inflationary factor. Through 2016 the program content is tightly constrained by budgetary limits and fully committed for executing existing program elements. 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 percent above inflation. (Note that the 2024 Enabling Budget is equivalent to growth at a rate just 0.50 percent above inflation from 2009.) GDC, the next large mission of the LWS program after SPP, rises above the baseline curve in order to achieve a more efficient spending profile, as well as to achieve deployment in time for the next solar maximum in 2024. Note: LWS refers to missions in the Living With a Star line and STP refers to missions in the Solar-Terrestrial Probes line.

(Continued from page 15)

example, NOAA and the U.S. Geological Survey (USGS). The committee anticipates the criticality of such a program growing in priority relative to other societal demands and envisions that NASA utilize its unique space-based capabilities as the basis for a new program that could provide sustained monitoring of key space environment observables to meet this pressing national need. In addition to ensuring the continuity of critical measurements, robust space environment models capable of operational deployment are also necessary for the prediction and specification of conditions where observations are lacking.

The committee anticipates that it will take decades to achieve a space environment weather and climatology infrastructure equivalent to current capabilities in the modeling and forecasting of terrestrial weather and climate; thus, it is necessary to start immediately. The committee's vision for achieving critical continuity of key space environment parameters, their utilization in advanced models and application to operations is a major endeavour that will require unprecedented cooperation among agencies in areas where they have specific expertise and unique capabilities.

Space Weather-Related Recommendations

The following recommendations were made by the survey committee to help fulfill its vision of an effective program in space weather that meets national needs—one that advances the fundamental science that underpins understanding of space weather phenomena and its effects on society and the evident need for effective vehicles to translate newly gained knowledge towards societal benefit:

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

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:

- 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.
- 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, the committee recommends that:

- **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.**
- **NOAA should establish a space weather research program to effectively transition research to operations.**
- **Distinct funding lines for basic space physics research and for space weather specification and forecasting need to be developed and maintained.**

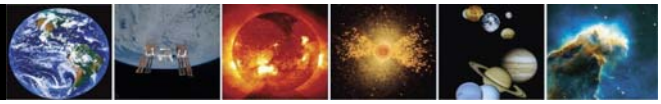
Implementation of a program to advance space weather and climatology will require funding well above what the survey committee assumes will be available to support its research-related recommendations to NASA. The committee emphasizes that implementation of an initiative in space weather and climatology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

Thank you again for the opportunity to bring to your attention the results of the 2nd National Research Council decadal survey in solar and space physics. At your request, I've focused my remarks on several questions that have particular relevance to NASA and its Science Mission Directorate; however, as the discussion of space weather indicates, multiple federal agencies have vital interests how we organize the nation's efforts in solar and space physics research and applications. In summary, our report:

- Fits the current fiscal boundary;
- Focuses on research and its societal impact;
- Empowers the community to innovate;
- Takes advantage of the unique constellation of missions and data available today and studies the coupled domains of heliophysics *as a system;*
- Builds the community's strength and facilitates development of cost-effective PI-class missions; and
- Recommends exciting missions of historical significance that hold tremendous promise for new discoveries.

[Dr. Baker's testimony also included a reprint of "Summary," *Solar and Space Physics: A Science for a Technological Society*, which can be found in the July-September 2012 newsletter.] □

[1] See, for example, National Research Council, *Severe Space Weather Events—Understanding Societal and Economic Impacts: A Workshop Report*, The National Academies Press, Washington, D.C., 2008, and D.N. Baker and L.J. Lanzerotti, A continuous L1 presence required for space weather, *Space Weather* 6:S11001, doi:10.1029/2008SW000445, 2008.



CONGRESSIONAL HEARINGS OF INTEREST, *CONTINUED*

The Future of NASA: Perspectives on Strategic Vision for America's Space Program

U.S. House of Representatives
Committee on Science, Space, and Technology Hearing
December 12, 2012

Hearing charter and testimony available at
<http://science.house.gov/legislation?type=hearing>

Witnesses: The Honorable Robert Walker, Wexler & Walker; Maj. Gen. Ronald Sega, USAF (Ret), Vice Chair, National Research Council Committee on NASA's Strategic Direction; The Honorable Marion C. Blakey, President & CEO, Aerospace Industries Association; Thomas Zurbuchen, Ph.D., Professor for Space Science and Aerospace Engineering, Associate Dean for Entrepreneurial Programs, University of Michigan; Scott Pace, Ph.D., Director, Space Policy Institute, George Washington University.

Ronald M. Sega. Credit: House Committee on Science, Space and Technology.

Written Testimony of
Ronald M. Sega
Colorado State University and The Ohio State University
and Vice Chair, Committee on NASA's Strategic Direction,
Division on Engineering and Physical Sciences
National Research Council, The National Academies

Mr. Chairman, Ranking Member Johnson, members of the committee, colleagues: I am Ron Sega, Vice Chair of the National Research Council's Committee on NASA's Strategic Direction. On behalf of Albert Carnesale, chair of this committee and our 12 members, it is my pleasure to come before you today to speak to you about the work of our committee. The National Research Council (NRC) is the operating arm of the National Academy of Sciences, National Academy of Engineering, and the Institute of Medicine of the National Academies, chartered by Congress in 1863 to advise the government on matters of science and technology. In late 2011, the United States Congress directed the NASA Office of the Inspector General to commission a "comprehensive independent assessment of NASA's strategic direction and agency management." Subsequently, NASA requested that the NRC conduct this independent assessment. In the spring of 2012, the NRC Committee on NASA's Strategic Direction was formed and began work on its task. (The full Statement of Task appears at the end of this written testimony.) I am here to report on the results of that study.

Our committee was charged with considering "the strategic direction of the agency as set forth most recently in 2011 NASA Strategic Plan and other relevant statements of space policy issued by the President of the United States." We were also charged with considering the goals of the agency as set forth in the 1958 National Aeronautics and Space Act as well as recent legislation, and with assessing the relevance of NASA's goals to national priorities. Finally, we were charged with recommending "how NASA could establish and effectively communicate a common, unifying vision for NASA's strategic direction that encompasses NASA's varied missions." Our committee was not charged with establishing strategic goals for NASA, and we did not do so.

Our committee consisted of members from industry and academia, former NASA aerospace officials, and former analysts and experts from both the executive and legislative branches. We met five times throughout 2012. The committee received input from nearly 800 members of the public through a web-based questionnaire, and small groups of committee members visited each of the nine NASA field centers and the Jet Propulsion Laboratory (JPL). Furthermore, the committee considered a large number of studies conducted by the NRC and other groups over the decades that made recommendations about the conduct of NASA's programs and the agency's future, as well as NASA's strategic plans dating back to 1986. The resulting report entitled: "NASA's Strategic Direction and the Need for a National Consensus" is a consensus report by the committee.

As I am sure you are aware, NASA has been tugged in multiple directions for the past several years. The agency has had many astonishing accomplishments. Just this past summer NASA landed the Curiosity rover on Mars, and spacecraft such as Cassini (which is orbiting Saturn), MESSENGER (which is orbiting Mercury), and New Horizons (which is speeding toward Pluto) are greatly expanding our understanding of the solar system and our place in it. Both the Hubble and Kepler space telescopes continue to make remarkable discoveries about our universe, with Kepler discovering dozens of planets orbiting distant stars. NASA spacecraft also collect vital data on Earth's condition and such information is used for many purposes, including improving computer models of how hurricanes form. NASA continues to operate, resupply, and maintain the International Space Station. NASA is also developing new commercial resupply and crew launch capabilities and working on a rocket and spacecraft to eventually take humans beyond low Earth orbit.

Despite these many, important activities, there remains a lack of consensus on the agency's future direction among the United States' political leadership. Without such a consensus, the agency cannot be expected to develop or work effectively toward long-term priorities. In addition, there is a mismatch between the portfolio of programs assigned to the agency and the budget allocated

(Continued from page 17)
by Congress.

What we found during the course of our deliberations was rather obvious: although NASA develops a strategic plan on a regular basis, the agency itself does not establish its strategic goals. Those are developed by the national leadership, and the key stakeholders within national leadership do not always agree on the goals the agency should pursue.

After considering the current situation facing NASA, the information collected by the committee, and the committee's own deliberations, the committee prepared a final report with the following recommendations regarding NASA's strategic goals and plans:

> **Recommendation:** The administration should take the lead in forging a new consensus on NASA's future that is stated in terms of a set of clearly defined strategic goals and objectives. This process should apply both within the administration and between the administration and Congress, and should be reached only after meaningful technical consultations with potential international partners. The strategic goals and objectives should be ambitious, yet technically rational, and should focus on the long term.
>
> **Recommendation:** Following the establishment of a new consensus on the agency's future, NASA should establish a new strategic plan that provides a framework for decisions on how the agency will pursue its strategic goals and objectives, allows for flexible and realistic implementation, clearly establishes agency-wide priorities to guide the allocation of resources within the agency budget, and presents a comprehensive picture that integrates the various fields of aeronautics and space activities.
>
> **Recommendation:** NASA's new strategic plan, future budget proposals prepared by the administration, and future NASA authorization and appropriation acts passed by Congress should include actions that will eliminate the current mismatch between NASA's budget and its portfolio of programs, facilities, and staff, while establishing and maintaining a sustainable distribution of resources among human spaceflight, Earth and space science, and aeronautics, through some combination of the kinds of options identified below by the committee. The strategic plan should also address the rationale for resource allocation among the strategic goals in the plan.

To reduce the mismatch between the agency's activities and the resources allocated to it, the White House, Congress, and NASA, as appropriate, could employ any or all of the following four (non-mutually exclusive) options. The committee does not recommend any one option or combination of options, but presents these to illustrate the scope of decisions and trades that could be made.

- *Option 1.* Institute an aggressive restructuring program to reduce infrastructure and personnel costs to improve efficiency.
- *Option 2.* Engage in and commit for the long term to more cost-sharing partnerships with other U.S. government agencies, private sector industries, and international partners.
- *Option 3.* Increase the size of the NASA budget.
- *Option 4.* Reduce considerably the size and scope of elements of NASA's current program portfolio to better fit the current and anticipated budget profile. This would require reducing or eliminating one or more of NASA's current portfolio elements (human exploration, Earth and space science, aeronautics, and space technology) in favor of the remaining elements.

Each of the above sample options, with the possible exception of Option 2, would require legislative action. Every option except for Option 3 would require substantial changes within NASA in order to substantially address the mismatch between NASA's programs and budget. Before implementation of any such options, the advantages and disadvantages, including possible unintended consequences, would deserve careful consideration. For example, if not handled carefully, Option 1 could constrain future mission options or increase future mission costs if unique facilities needed by future missions were decommissioned. Option 1 might also diminish NASA's workforce capabilities if changes in policies were to prompt large numbers of key personnel to retire or seek other employment. To be effective, Option 2 might require congressional authorization for NASA to make long-term financial commitments to a particular program to assure prospective partners that neither NASA nor the Congress would unilaterally cancel a joint program. Option 3, of course, is ideal from NASA's perspective, but its selection also seems unlikely given the current outlook for the federal budget. Option 4 is perhaps the least attractive, given the value of each major element in NASA's portfolio.

The Role and Management of NASA's Field Centers

The success of NASA's past, present, and future endeavors in aeronautics and space would be impossible without the contributions of the field centers and JPL. However, changes in the goals, funding, staffing, and facility requirements of NASA programs, as well as changes in the goals, activities, and capabilities of other government agencies and industry, imply that changes in the operation of the NASA field centers are warranted.

During its visits to the NASA centers, JPL, and from testimony of NASA headquarters leadership, our committee heard that NASA's leadership desires more flexibility in general to manage their facilities. The committee determined that two particular areas where flexibility can be improved are especially relevant:

- *Personnel flexibility*. NASA is restricted by law from performing reductions in-force (RIFs). The prohibition is currently in the 2010 NASA Authorization Act, which expires at the end of FY2013. Congress could act before then (for instance, in an appropriations act) to repeal that language—or could omit the language from new authorization and new appropriations acts. In addition, NASA could be given the ability to convert civil service positions to contractor positions in select instances.
- *Infrastructure flexibility*. The General Services Administration (GSA) imposes restrictions on government agencies charging less than fair market value for facilities, making it difficult for NASA to dispose of facilities it no longer needs. Easing such restrictions for NASA could save the government money by not having to maintain or demolish buildings no longer required by NASA. In addition, current regulations require that disposed property first be offered to state and local governments, a requirement that could

(Continued from page 18)

slow down or hinder the ability to find private users. If NASA were given more authority to manage its infrastructure instead of leaving this process to GSA, the agency could take better advantage of opportunities in the private sector.

The committee recognizes that personnel and infrastructure restrictions have been imposed upon NASA, as well as the federal government in general, for many valid reasons. Naturally, any changes would require careful consideration and evaluation by the legislative and executive branches, but they demonstrate that not all solutions require additional money, and legislative and policy changes can play an important role as well.

Recommendation: With respect to NASA centers:

- The administration and Congress should adopt regulatory and legislative reforms that would enable NASA to improve the flexibility of the management of its centers.
- NASA should transform its network of field centers into an integrated system that supports its strategic plan and communications strategy and advances its strategic goals and objectives.

Although the committee lacked the capability and time to conduct the detailed supporting analysis required to make specific recommendations for changes in NASA's infrastructure, the committee did conclude that better coordination with other relevant government agencies is required:

Recommendation: NASA should work with other U.S. government agencies with responsibilities in aeronautics and space to more effectively and efficiently coordinate the nation's aeronautics and space activities.

The Role of International Cooperation

Today it is common to say that all future human spaceflight or large-scale Earth and space science projects will be international. Many U.S. leaders also assume that the United States will take the lead in such projects. However, U.S. leadership in international space cooperation requires that several conditions be met. First, the United States must have a program that other countries want to participate in, which has not always been the case. Second, the United States must be willing to have substantial responsibilities assumed by its partners. In the past, the approach of the United States to international partnership has too often been perceived as being based on a program conceived, planned, and directed by NASA. Third, other nations must be able to see something to gain, in other words, a reason to partner with the United States. Finally, the United States must demonstrate its reliability and attractiveness as an international partner.

Recommendation: The United States should explore opportunities to lead a more international approach to future large space efforts both in the human space program and in the science program.

Conclusion

The committee was impressed with the quality of personnel and the level of commitment of NASA's civil service and contractor staffs and with the superb quality of the work done by the agency in general. However, the committee also heard about the frustration of many staff with the agency's current path and the limitations imposed upon it by the inability of the national leadership to agree upon a long-term direction for the agency.

Only with a national consensus on the agency's future strategic direction, along the lines described in this report, can NASA continue to deliver the wonder, the knowledge, the national security, and economic benefits, and the technology that has typified its history.

Thank you for the opportunity to testify. I would be pleased to respond to any questions the Committee might have.

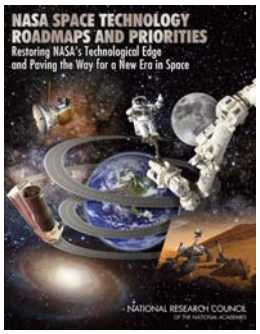
[Mr. Sega's statement also included the committee statement of task, which can be found in Appendix A of the report.]

[Thomas H. Zurbuchen, University of Michigan, also testified, but not on behalf of the National Academies. Dr. Zurbuchen is a member of the Space Studies Board and is Vice Chair of the Decadal Survey in Solar and Space Physics.]

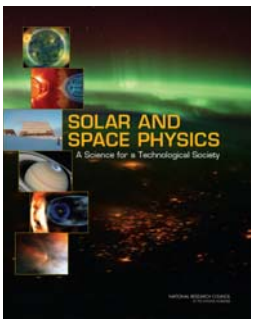
■

2012 Top 50 Downloads

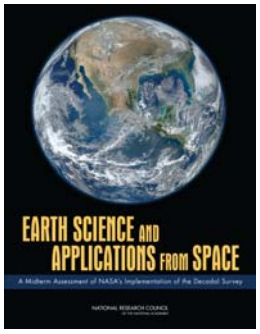
Three SSB or ASEB reports were included in our publisher's list of the top 50 most downloaded reports from www.nap.edu this past year. See the National Academies Press list at <http://notes.nap.edu/2012/12/20/top-titles-of-2012/#.UNN7Q6zNl8F>.



NASA Space Technology Roadmaps and Priorities: Restoring NASA's Technological Edge and Paving the Way for a New Era in Space (ASEB)



Solar and Space Physics: A Science for a Technological Society (SSB/ASEB)



Earth Science and Applications from Space: A Midterm Assessment of NASA's Implementation of the Decadal Survey (SSB)

STAFF NEWS

In November, ASEB Program Associate **Andrea Rebholz** earned the Certified Meeting Professional designation from the Convention Industry Council. The CMP program recognizes individuals who have achieved the meeting industry's highest standard of professionalism.

2012 Staff Awards and Staff Appreciation Day

On November 5, the National Academies honored more than 80 employees for their outstanding contributions to the work of the Academies. **Christina Shipman,** Financial and Administrative Officer for ASEB and SSB, received an Individual Service Award. Chris has been with the National Research Council for 37 years.

Division on Engineering and Physical Sciences 2012 Staff Achievement Awards

The recipients of the 2012 DEPS Staff Achievement Awards have been announced. **Dionna Williams** of SSB will receive the Inspiration Award, and staff for the study on **NASA Strategic Directions**, **Dwayne Day , Alan Angleman**, and **Amanda Thibault** of ASEB and **David Smith**, **Danielle Piskorz**, **Linda Walker**, and **Cathy Gruber** of SSB will be honored with the DEPS Team Award.

Christine Mirzayan Science and Technology Policy Graduate Fellowship Program

The Christine Mirzayan Science and Technology Policy Graduate Fellowship Program within the Policy and Global Affairs Division of the National Academies is designed to engage its fellows in the analytical process that informs U.S. science and technology policy. Fellows develop basic skills essential to working or participating in science policy at the federal, state, or local levels. More information can be found at <http://sites.nationalacademies.org/PGA/policyfellows/index.htm>.

Cheryl Moy completed her Fall 2012 Mirzayan Fellowship with the Aeronautics and Space Engineering Board (shared with the SSB). Her reflections on her experience with the SSB appear below.

I was awarded my Ph.D. in chemistry very recently, so I went from spending all day in front of a fume hood making molecules to delving deep into the world of space policy for 3 months. During my time here, I not only participated and gained insight into the process of developing a National Research Council report, but I also worked with SSB staff to analyze current and emerging policy issues and sculpt potential studies. My most influential experience was the opportunity to attend the Lessons Learned in Decadal Planning Workshop where I learned how valuable the decadal surveys were to the academic community and agencies like NASA, NSF, and NOAA, and better understood the influence these reports had on the policymaking process.

As an early-career scientist, this fellowship was an invaluable opportunity for me to explore careers in space policy. It has been rewarding to work closely with and to learn from the SSB staff whom have incredible expertise in their fields and are very knowledgeable in communicating and working with policymakers. I attended congressional hearings, drafted summaries for SSB board members and staff, compiled background information for committees, gained a better understanding of how NASA operates, and participated in discussions with various stakeholders on what they could contribute to a study.

Through my work, I developed the skills necessary to approach a sensitive topic and gather rational insight to the emotionally charged political issue of human spaceflight. During my graduate career, a majority of my time was spent thinking and speaking to colleagues on a very technical level; however, this experience with the SSB has required me to shift my thinking toward the broad implications of space science research to better convey its importance. The knowledge I gained during this fellowship will contribute significantly to my career goal of working within a university's government affairs office and developing policies surrounding the university's research portfolio. I am grateful to everyone I interacted with during my fellowship, especially the SSB staff.

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>. The SSB is accepting applications for the Summer 2013 program (see page 6).

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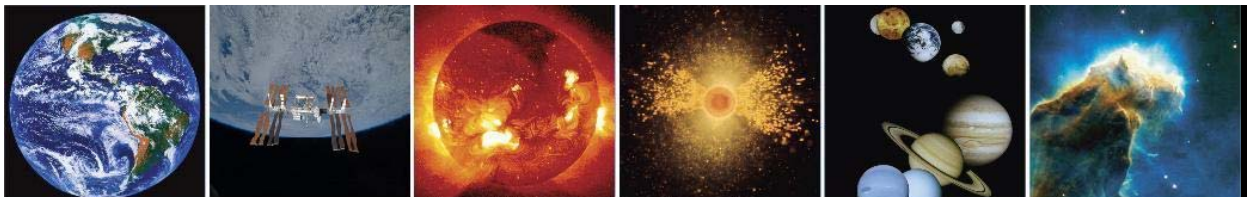
* Staff of other NRC boards who are shared with the SSB.
† Through January 4, 2013.
‡ Through December 21, 2012.



SSB Calendar

JANUARY

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January 8	Committee on Human Spaceflight (ASEB-led)	Stanford, CA, and Washington, DC
February 4-5	Committee on Human Spaceflight (ASEB-led): Technical Feasibility Panel	Washington, DC
March 6-8	NRC Space Science Week (CAA, CAPS, CESAS, CSSP)	Washington, DC
April 4-5	Space Studies Board (with ASEB on April 4)	Washington, DC

Future SSB Meetings

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

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- ☐ 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 [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)
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