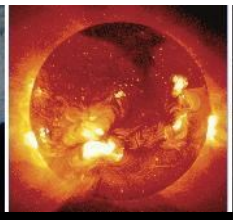
# SPACE STUDIES BOARD NEWS





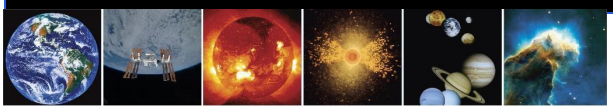

APRIL—JUNE 2014

## Inside This Issue

*"Even with a flat budget, NASA will likely spend roughly $160 billion on human space flight of the next 20 years—all of us who are part of the space policy community need to make sure that this substantial investment brings humanity closer to reaching Mars. "*

*—SSB Chair David Spergel*

# SPACE STUDIES BOARD NEWS



## FROM THE CHAIR

Under the leadership of Jonathan Lunine and Mitch Daniels, the Committee on Human Spaceflight has recently completed one of the most challenging studies undertaken by the Space Studies Board and the Aeronautics and Space Engineering Board. In "Pathways to Exploration – Rationales and Approaches for a US Program of Human Exploration", a diverse committee of experts tackled not only "how should humans explore space?", but the even more challenging question of "why should humans explore space?"

Space exploration is a dangerous and expensive undertaking with limited immediate return. What are the benefits provided to the US and other countries by space exploration? What would the nation and the world lose if we abandoned human exploration? Through analyzing broad public surveys, white papers, Twitter conversations, and surveys of stakeholders in different aspects of civilian space, the committee identified a pair of enduring questions that motivate human space flight: How far from Earth can humans go? and What can humans discover and achieve when we get there? The committee then explored a range of rationales for human spaceflight ranging from the pragmatic (its economic, national security, scientific exploration, international relations and technology impacts) to the aspirational—the notion that space is humanity's future. While they did not identify a single rationale as the primary justification for space exploration and could not quantify the economic benefit of space exploration, they did conclude that the mix of rationales motivates space exploration. My own personal hope is that the effort of striving towards Mars as a common goal for humanity will have important impacts on how we interact as nations and individuals on Earth.

Mars is the clear horizon goal for human space exploration. Across several administrations and multiple changes in political control of the House, Senate and White House, there has been a broad consensus that NASA human spaceflight path should lead towards Mars. Nevertheless, progress towards this goal has been slow. As the committee details in its technical section, human exploration of Mars is a daunting, difficult and expensive task. A Mars mission will require significant progress in advanced in-space propulsion and power, technologies for entry, descent and landing on Mars, and radiation safety. These challenges are all technically hard, but none are impossible. With a sustained and focused human spaceflight program, we can overcome these hurdles.

Are we making the best possible progress towards Mars? The committee identified a number of potential problems with our current path. The nation's near-term goals for human exploration beyond Low Earth Orbit are not aligned with our traditional international partners. The US program is focused on the Asteroid Redirect Mission (ARM) while our Space Station partners are more eager to go back to the Moon. ARM may not be the optimal pathway towards developing the most critical technologies. The committee recommended that NASA adopt a "Pathway" approach that leads to a sustainable program that is less likely to be disrupted by the inevitable technological failures and accidents along the way and is less sensitive to the vagaries of politics and economics. In addition, the committee urged NASA to work with commercial and international partners in pursuit of the chosen pathway, while also noting that the prohibition on NASA speaking to the Chinese space authorities limits our ability to work with an important potential partner.

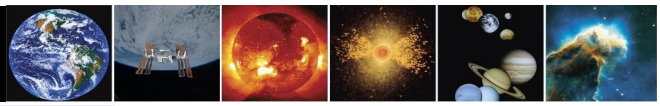
Historically, one of the Space Studies Board's most important tasks has been to conduct and then steward the decadal surveys that have provided strategic direction for NASA's science program. During my tenure as Space Studies Board chair, I believe that my most important task is to continue this tradition. While the "Pathways to Exploration" is not a decadal survey, I hope that the SSB will play a role in stewarding this study. Even with a flat budget, NASA will likely spend roughly $160 billion on human space flight over the next 20 years—all of us who are part of the space policy community need to make sure that this substantial investment brings humanity closer to reaching Mars.

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

Pathways to Exploration: Rationales and Approaches for a U.S. Program of Human Space Exploration

Download a free copy via the National Academies Press at

<http://www.nap.edu/catalog.php?record_id=18801>



## SSB MEMBERSHIP

**JULY 1, 2013—JUNE 30, 2014**

**CHARLES F. KENNEL,** ***CHAIR***
Scripps Institution of Oceanography, University of California, San Diego

**JOHN KLINEBERG,** ***VICE CHAIR***
Former CEO of Swales Aerospace

**MARK R. ABBOTT**
Oregon State University

**JAMES ANDERSON**
Harvard University

**JAMES BAGIAN**
University of Michigan

**THOMAS R. GAVIN**
Jet Propulsion Laboratory

**NEIL GEHRELS**
NASA Goddard Space Flight Center

**SARAH GIBSON**
National Center for Atmospheric Research

**HEIDI B. HAMMEL**
AURA

**RODERICK HEELIS**
The University of Texas

**JOSEPH S. HEZIR**
EOP Group, Inc.

**WESLEY HUNTRESS**
Carnegie Institution of Washington

**ANTHONY C. JANETOS**
Boston University

**JOAN JOHNSON-FREESE**
U.S. Naval War College

**JOSEPH FULLER, JR**
Futron Corporation

**JOHN F. MUSTARD**
Brown University

**DAVA J. NEWMAN**
Massachusetts Institute of Technology

**ROBERT T. PAPPALARDO**
Jet Propulsion Laboratory, California Institute of Technology

**SAUL PERLMUTTER**
Lawrence Berkeley National Laboratory

**MARCIA J. RIEKE**
University of Arizona

**DAVID N. SPERGEL**
Princeton University

**MEENAKSHI WADHWA**
Arizona State University

**CLIFFORD M. WILL**
University of Florida

**THOMAS H. ZURBUCHEN**
University of Michigan

LIAISON

**LENNARD A. FISK**
*U.S. REPRESENTATIVE TO COSPAR*

**JULY 1, 2014—JUNE 30, 2015**

**DAVID N. SPERGEL,** ***CHAIR***
Princeton University

**JOHN KLINEBERG,** ***VICE CHAIR***
former CEO of Swales Aerospace

**MARK R. ABBOTT**
Oregon State University

**JAMES ANDERSON**
Harvard University

**JAMES BAGIAN**
University of Michigan

**JEFF M. BINGHAM**
Consultant

**PENELOPE J. BOSTON**
New Mexico Institute of Mining and Technology

**JOSEPH FULLER, JR**
Futron Corporation

**THOMAS R. GAVIN**
Jet Propulsion Laboratory

**NEIL GEHRELS**
NASA Goddard Space Flight Center

**SARAH GIBSON**
National Center for Atmospheric Research

**RODERICK HEELIS**
The University of Texas

**WESLEY HUNTRESS**
Carnegie Institution of Washington

**ANTHONY C. JANETOS**
Boston University

**DAVA J. NEWMAN**
Massachusetts Institute of Technology

**SAUL PERLMUTTER**
Lawrence Berkeley National Laboratory

**LOUISE M. PROCKTER**
Johns Hopkins University, Applied Physics Laboratory

**MARCIA J. RIEKE**
University of Arizona

**MARK THIEMENS**
University of California, San Diego

**MEENAKSHI WADHWA**
Arizona State University

**CLIFFORD M. WILL**
University of Florida

**THOMAS H. ZURBUCHEN**
University of Michigan

LIAISON

**LENNARD A. FISK**
*U.S. REPRESENTATIVE TO COSPAR*

# SSB ACTIVITIES

## THE BOARD AND ITS STANDING COMMITTEES

The **Space Studies Board (SSB)** met April 3-4. April 3 was a joint session with the Aeronautics and Space Engineering Board (ASEB) where both boards participated in a roundtable discussion with the NASA chiefs (David Miller, NASA Chief Technologist; Ralph Roe, NASA Chief Engineer; and Ellen Stofan, NASA Chief Scientist), followed by an update from and discussion with NASA Administrator Charles Bolden. The boards then participated in a discussion with representatives from the White House, Grace Hu and Paul Shawcross from the Office of Management and Budget, and Richard Dalbello from the Office of Science and Technology Policy. The boards then received an update on the activities of NASA's Human Exploration and Operations Mission Directorate (HEOMD) and held a discussion with William Gerstenmaier, Associate Administrator of HEOMD. On April 4 the SSB heard updates from the leadership of the four standing committees in their purview, the Committee on Astronomy and Astrophysics, the Committee on Astrobiology and Planetary Sciences, the Committee on Earth Science and Applications from Space, and the Committee on Solar and Space Physics. The board was updated on the activities of the European Space Sciences Committee (ESSC) by Jean Pierre Swings (current ESSC Chair) and Athena Coustenis (Chair-elect) and on the activities of COSPAR by the US COSPAR Representative Len Fisk. The board also received updates from and participated in a roundtable discussion with John Grunsfeld, Associate Administrator of the Science Mission Directorate (SMD) and the SMD division directors or their representatives. Finally, the board received an update from and participated in a discussion with Kathryn Sullivan, Under Secretary of Commerce for Oceans and Atmosphere and NOAA Administrator on NOAA's Earth observation and space weather programs. Visit <www.nas.edu/ssb> to stay up to date on board, workshop, and study committee meetings and developments.

The **Committee on Astronomy and Astrophysics (CAA)** did not met during this quarter. In July, the committee held a teleconference with National Science Foundation (NSF) Astronomy Division staff to discuss a proposed new policy to encourage proposers to limit the number of proposals they submit to the grants program. The committee is currently planning its Fall 2014 meeting, to be held November 3-4, in Irvine, CA. For more information about CAA, to learn about upcoming meetings, and download presentations from past meetings, please visit <sites.nationalacademies.org/BPA/BPA_048755>.

Recommended candidates for membership on the **Committee on Biological and Physical Sciences in Space (CBPSS**) were reviewed with committee co-chairs Betsy Cantwell and Rob Ferl, and a slate was selected for nomination. Approval is expected by August, and the first meeting of the committee is likely to take place in the September/October timeframe. During this period, staff officer Sandra Graham attended the 3rd Annual International Space Station (ISS) Research and Development Conference on June 17-19, 2014, in Chicago, IL, and co-chair Betsy Cantwell participated in an ISS Science Forum on May 21 at Johnson Space Center.

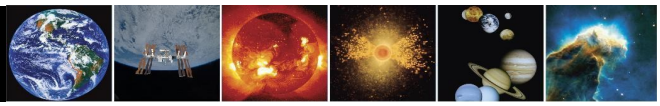
The **Committee on Earth Science and Applications from Space** (CESAS) met on June 3-4 at the Beckman Center in Irvine, CA. This meeting, like the previous meeting in March 2014 whose attendance was limited because area airports closed due to a major snowstorm, focused on planning for the second NRC decadal survey in Earth science and applications from space, which will get underway in early 2015. The committee discussed with representatives from the Aerospace Corporation options for the cost and technical evaluation that is now an integral part of all NRC decadal surveys. The committee also met with Piers Sellers and Colleen Hartmann from NASA's Goddard Space Flight, Center, who reviewed their recent white paper on the future of the U.S. environmental satellite program.

Follow-on roundtable discussions among the committee and guests focused on issues related to the development of the statement of task for the upcoming survey:

- Survey objectives and scope;
- How to better tailor the next survey to the different needs and missions of relevant stakeholder agencies (NASA,NOAA, and USGS);
- Status of the previous decadal survey recommendations and missions, and their role in the next survey;
- Striking the right balance between prioritizing "science" and prioritizing missions;
- Role and scope of the cost and technical evaluation (CATE) process in the next decadal survey;
- Tension between continuity and new missions and incorporating results of the NRC "Continuity" study;
- Coordinating with international partners;
- Developing meaningful and actionable decision rules;
- How to engage the community while managing expectations; including what template other NRC committees should use to communicate their community's observational needs to the survey; and
- Potential panel structure.

A key product of the meeting, developed in executive session, was a draft of suggested elements of a statement of task. The committee's next meeting will take place on September 17-19, 2014, in Washington, DC. Information about the meeting will be posted on the committee's website at <http://sites.nationalacademies.org/SSB/SSB_066587.htm>.

The **Committee on Astrobiology and Planetary Science (CAPS)** did not meet during this quarter. The committee welcomed one new member to its ranks: James Kasting (Pennsylvania State University). The committee's second and final scheduled meeting of 2014 will take place at the National Academies' Beckman Center in Irvine, CA, on September 3-4. Preliminary planning is underway to enable CAPS to hold joint sessions (via teleconference) with the Planetary Science Subcommittee of the NASA Advisory Council during its September 3-4 meeting in Washington, DC. In the interim, the committee plans to hold a series of semi-regular con-



*(Continued from page 4)*

ference calls to stay abreast of new developments. More information about CAPS is available at <sites.nationalacademies.org/SSB/SSB_067577>.

The **Committee on Solar and Space Physics** (CSSP) did not meet in-person during this quarter; the committee did meet several times by WebEx teleconference, including a discussion with then-Director of NASA's Heliophysics Division (HPD) David Chenette. Among the topics discussed with Dr. Chenette were the budget and status of the Solar Probe Plus mission, implementation of the 2012 solar and space physics decadal survey, proposal success rates, and the health of the research community.

The committee also held a WebEx teleconference with Richard Behnke, head of the Geospace Section of the NSF's Division of Atmospheric and Geospace Sciences (GEO/AGS). Topics of discussion included the status of GEO/AGS programs, the potential to move one of the AMISR faces to Gakona, AK, for coordinated operations with the existing HAARP facility (assuming HAARP continues to operate), and potential future activities related to national needs for improved forecasts of space weather events. The committee also continued to edit a planned popularization of the decadal survey. The next in-person meeting of the committee will occur on October 7-9, 2014, in Washington, DC. Further information about CSSP, including future meetings, is available at <http://sites.nationalacademies.org/SSB/ssb_052324>.

## STUDY COMMITTEES

The ad hoc **Committee on a Framework for Analyzing the Needs for Continuity of NASA-Sustained Remote Sensing Observations of the Earth from Space** held its 3rd and 4th in-person meetings from April 23-25 at the Beckman Center in Irvine, CA, and June 10-12 at the Keck Center in Washington, DC. Both meetings were closed in their entirety and were devoted to developing a draft of the committee's report, which is now targeting release in pre publication form for the end of this calendar year. Additional information about the committee and its work is available at <http://sites.nationalacademies.org/SSB/CurrentProjects/SSB_084713>.

The final reviews for the draft report of the ad hoc **Committee on Human Spaceflight** arrived in early May and the committee completed its work to address the comments of the 19 external experts by the end of that month. Following institutional sign-off, the prepublication report, ***Pathways to Exploration—Rationales and Approaches for a U.S. Program of Human Space Exploration*** was delivered to NASA on May 30 and publicly released on June 4. NASA Administrator Charles Bolden and other agency leaders were briefed on June 3 by committee Co-Chairs Jonathan Lunine and Mitch Daniels and Technical Panel Chair John Sommerer on the report findings. The chairs also provided a joint briefing to OMB/OSTP staff on June 3, a separate briefing to Senate and House staffers that afternoon, and a briefing to other House staffers the following day. A well-attended press conference for the report was held on June 4, and the three chairs, along with Pubic and Stakeholder Opinions Panel Chair Roger Tourangeau, made a presentation to both live and remote audiences and answered questions from both. The report was well received at all of these briefings, and at each, the chairs were extensively questioned about the findings and implications of the report.

The report's release was met by intense interest from both the space press and the general press, and articles quickly appeared in a number of national newspapers including the *Washington Post*. Both the chairs and members of the committee have given numerous press and radio interviews to date and continue to receive requests for interviews and formal presentations. On June 25, Co-Chairs Lunine and Daniels gave invited testimony as the only witnesses at a House Committee on Science, Space and Technology hearing on the future of human spaceflight.

Currently, dissemination activities and final editing of the report are continuing, with a publication of the final report expected by October 2014. Detailed information on this congressionally requested study, and links to the public briefing and other release products, can be found at <www.nationalacademies.org/humanspaceflight>.

With funding from the NSF the NRC has begun a study that will recommend **A Strategy to Optimize the U.S. Optical/Infrared System in the Era of the Large Synoptic Survey Telescope.** The statement of task to this committee is given here:

> "In order to position the observational, instrumentation, data management, and support capabilities of the U.S. optical and infrared astronomy (O/IR) system to best address the science objectives identified in the 2010 report entitled *New Worlds, New Horizons in Astronomy and Astrophysics and Vision and Voyages for Planetary Sciences in the Decade 2013-2022* and to help achieve the best science return from the National Science Foundation investment in O/IR astronomy over the next 10-15 years, the National Research Council will convene a committee to write a short report that will recommend and prioritize adjustments to the U.S. ground-based O/IR system that will better position the system to address the New Worlds, New Horizons science objectives over the next 10-15 years. The committee will consider needs and strategies for several interrelated components of the system: existing and planned focal plane instrumentation; focal plane instrumentation and technology development; and data management, processing, mining, and archiving. The committee may make recommendations or offer comments on organizational structure, program balance, and funding, with discussion of the evidentiary bases, as appropriate."

The committee was appointed in July 2014 and will be led by Debbie Elmegreen (Vassar College), and its first meeting will be held July 31-August 1, in Washington, DC. The second meeting will be October 12-13, in Irvine, CA and the third meeting will be December 2-3, in Washington, DC. The NRC convened a town hall at the June 2014 meeting of the American Astronomical Society in Boston, MA, to engage the community in a discussion of issues relevant to the study. Dr. Elmegreen and several CAA members spoke at the town hall. For more information about the commit-

*(Continued from page 5)*

tee, please visit <http://sites.nationalacademies.org/BPA/BPA_087934>.

The ad hoc **Committee on Survey of Surveys: Lessons Learned from the Decadal Survey Process** which is undertaking the study following on from the SSB's November 2012 workshop on lessons learned from the decadal survey process, was formally appointed in mid-May and held their first meeting at the National Academies Keck Center in Washington, DC, on June 23-24. The committee, under the leadership of Alan Dressler (Carnegie Observatories) has been tasked to identify a set of major lessons learned from the recent decadal survey planning process and present a set of options for possible evolutionary changes and improvements to this process. The committee is paying particular attention to the development of decadal statements of task, as well as advanced preparatory activities and the organization and execution of the surveys. The committee plans to hold subsequent meetings on-August 25-27, in Washington, DC, and December8-10, in Irvine, CA. A report will be released in the second quarter of 2015. More information about the committee can be found at http://www8.nationalacademies.org/cp/projectview.aspx?key=49635.

## OTHER ACTIVITIES

### U.S PARTICIPATION IN COSPAR 2014 IN MOSCOW, RUSSIA

**COSPAR** will hold its 40th Scientific Assembly in Moscow. Despite the best efforts of the SSB, acting in its capacity as U.S. National Committee for COSPAR, it is anticipated that the number of U.S. scientists attending the assembly will be small relative to other recent such activities. On the positive side, following encouragement from COSPAR's Bureau and Secretariat, an informal exploratory committee was established in April to examine the possibility of holding the 2018 COSPAR Scientific Assembly in the United States. The exploratory committee's activities have proved successful. On June 24, NAS President Ralph Cicerone issued a formal invitation to COSPAR to meet in the United States in 2018. A bid to hold the 42nd Scientific Assembly in Pasadena, California, will be presented to the COSPAR Council during its meeting in Moscow on August 2. COSPAR is expected to make a decision concerning the venue for its 2018 assembly before the end of its Moscow meeting.

### NRC Space Science Week 2015

**NRC Space Science Week 2015 is scheduled for March 31-April 2, 2015.** All five of the SSB standing committees (shown below) will be meeting. This will be the first year that the Committee on Biological and Physical Sciences in Space will be joining (the first meeting of the CBPSS is expected to occur in the fall of 2014).

## SSB STANDING COMMITTEES

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

Paul L. Schechter, MIT (Co-Chair)
Co-Chair in the process of being appointed

**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 Biological and Physical Sciences in Space (CBPSS)**
(joint with the Aeronautics and Space Engineering Board)

Elizabeth Cantwell, Lawrence Livermore National Laboratory (Co-Chair)
Robert J. Ferl, University of Florida (Co-Chair)

**Committee on Earth Science and Applications from Space (CESAS)**

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

**MICHAEL H. MOLONEY**
Director

**ARTHUR A. CHARO**
Senior Program Officer

**SANDRA J. GRAHAM**
Senior Program Officer

**DAVID H. SMITH**
Senior Program Officer

**DWAYNE A. DAY***
Senior Program Officer

**DAVID LANG***
Program Officer

**ABIGAIL SHEFFER**
Associate Program Officer

**LEWIS GROSWALD****
Associate Program Officer

**ANDREA REBHOLZ***
Program Associate

**DIONNA WILLIAMS**
Program Associate

**ANESIA WILKS**
Program Assistant

**CARMELA J. CHAMBERLAIN**
Administrative Coordinator

**MEG KNEMEYER**
Financial Officer

**CELESTE A. NAYLOR**
Information Management Associate

**TANJA E. PILZAK**
Manager, Program Operations

**CHRISTINA O. SHIPMAN**
Financial Officer (part-time)

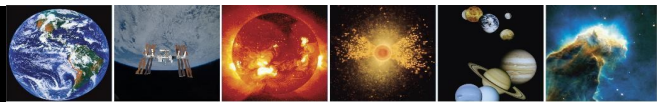
**SANDRA WILSON**
Senior Financial Assistant

**EVAN LINCK**
Lloyd V. Berkner Space Policy Intern

**IAN SZUMILA**
Lloyd V. Berkner Space Policy Intern

* Staff of other NRC boards who are shared with the SSB.

**through June 20



# NEW RELEASE

## *Pathways to Exploration: Rationales and Approaches for a U.S. Program of Human Space Exploration*

The United States has publicly funded its human spaceflight program on a continuous basis for more than a half-century, through three wars and a half-dozen recessions, from the early Mercury and Gemini suborbital and Earth orbital missions, to the lunar landings, and thence to the first reusable winged crewed spaceplane that the United States operated for three decades. Today the United States is the major partner in a massive orbital facility - the International Space Station—that is becoming the focal point for the first tentative steps in commercial cargo and crewed orbital space flights. And yet, the long-term future of human spaceflight beyond this project is unclear. Pronouncements by multiple presidents of bold new ventures by Americans to the Moon, to Mars, and to an asteroid in its native orbit, have not been matched by the same commitment that accompanied President Kennedy's now fabled 1961 speech-namely, the substantial increase in NASA funding needed to make it happen. Are we still committed to advancing human spaceflight? What should a long-term goal be, and what does the United States need to do to achieve it?

*Pathways to Exploration* explores the case for advancing this endeavor, drawing on the history of rationales for human spaceflight, examining the attitudes of stakeholders and the public, and carefully assessing the technical and fiscal realities. This report recommends maintaining the long-term focus on Mars as the horizon goal for human space exploration. With this goal in mind, the report considers funding levels necessary to maintain a robust tempo of execution, current research and exploration projects and the time/resources needed to continue them, and international cooperation that could contribute to the achievement of spaceflight to Mars. According to *Pathways to Exploration*, a successful U.S. program would require sustained national commitment and a budget that increases by more than the rate of inflation.

In reviving a U.S. human exploration program capable of answering the enduring questions about humanity's destiny beyond our tiny blue planet, the nation will need to grapple with the attitudinal and fiscal realities of the nation today while staying true to a small but crucial set of fundamental principles for the conduct of exploration of the endless frontier. The recommendations of *Pathways to Exploration* provide a clear map toward a human spaceflight program that inspires students and citizens by furthering human exploration and discovery, while taking into account the long-term commitment necessary to achieve this goal.

Authors include the Committee on Human Spaceflight and study director Sandra Graham. *Other staff are listed in the report.*

The full text of the report, including a downloadable pdf, is available at <http://www.nap.edu/catalog.php?record_id=18801>.

# CONGRESSIONAL TESTIMONY

**Committee on Science, Space, and Technology**
**U.S. House of Representatives**

**June 25, 2014**

Governor Mitch Daniels
President of Purdue University
and
Professor Jonathan Lunine, Ph.D.
David C. Duncan Professor in the Physical Sciences
Cornell University

Co-Chairs, Committee on Human Spaceflight
Division on Engineering and Physical Sciences
National Research Council
The National Academies

*The archived webcast is available at <http://science.house.gov/hearing/full-committee-hearing-pathways-exploration-review-future-human-space-exploration>.*

**[Governor Daniels begins]**

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

Thank you for the opportunity to speak to you today on issues concerning the nation's human spaceflight program. Today my co-chair Jonathan Lunine and I are here to represent the National Research Council's Committee on Human Spaceflight, established in response to the NASA Authorization Act of 2010. That act called on NASA to ask the National Academies to review the goals, core capabilities, and direction of our nation's human spaceflight program. After about 18 months of work we released our report on June 5th and Dr. Lunine and I are here today to briefly summarize its contents. The executive summary of that report which you have before you contains a lot more detail than we might cover today. And indeed I would urge interested members to read Chapter 1 of our report, which contains all our detailed findings and recommendations.

As envisioned in the 2010 Act, the background of our committee's membership was very diverse. This committee was not composed solely or even mostly of experts from the human spaceflight community—as might have been the case with other major reports on this topic in the past—but instead had members from fields as diverse as planetary science, astronomy, political science and history, sociology, public opinion and polling, economics, human spaceflight experience, international peace and security, and so on. Although all of us came into this process with open minds and brought to the work divergent points of view, in the end we came to the strong consensus that there is a convincing case to be made for a continuation of our nation's human spaceflight program, provided that the pathways approach and decision rules recommended in our report are adopted.

Why did we come to that position? We did so because we became convinced through lengthy discussion and analysis that a

combination of what we call the pragmatic and aspirational rationales, including the human impulse to explore and search for new knowledge in places we have never been, justifies the cost, risk and opportunities associated with sending humans beyond low Earth orbit—especially toward the "horizon goal" we identified as Mars.

Getting humans to the surface of Mars will be a daunting challenge. It is immensely difficult, probably more so than most laymen and even many experts have recognized. Succeeding in this endeavor will require a very different way of doing business than the nation has been practicing in recent decades, particularly as it is likely to take thirty years or more for us to reach our goal.

With this challenge in mind, as its highest priority recommendation, the committee recommends what we call a "pathways approach", which would require the government to come to a consensus on achieving a highly disciplined set of objectives from which the nation would not deviate over time. A pathway in this scenario would involve a pre-defined set of chosen destinations and milestones—stepping stones if you will—each of which would generate technical and engineering requirements which, as much as possible, would feed forward toward the next step and eventually the horizon goal. The committee does not recommend any specific pathway, but we do note in our report that any pathway that could successfully land humans on the surface of Mars would require funding above constant dollars. Pursuing unwaveringly the consensus choice of a pathway over the long term of multiple decades and the sustained support of the technical advances required by the resulting exploration architecture are the keys to unlocking a sustainable approach to human spaceflight for our nation.

Mr. Chairman, I cannot stress enough how critical it is that this nation takes a new approach that goes beyond the recent way of doing business in space. We need to come to a consensus on the pathway of choice if we are going to decide to continue to pursue human exploration beyond low Earth orbit. Work needs to begin soon on the most difficult and mission-critical technical challenges of any pathway to Mars: out of many such challenges, we single out Mars entry, descent and landing; in-space propulsion and power; and radiation safety for special emphasis. In addition we were in total agreement that achieving the goal of a human presence on Mars will require the U.S. to expand its partnerships with other spacefaring nations, including an openness to working with China with whatever safeguards we might have to put in place. Such international partnerships should include much greater cost-sharing than our partners have provided up to now, but that can only happen if those partners are given the responsibility to provide substantive and substantial elements to the overall architecture, which they will help design and build. Indeed our committee's report clearly states that our human spaceflight program should engage with any partner—governmental or commercial—that can help solve technical and programmatic impediments to pathway progress.

Finally, Mr. Chairman, Ms. Johnson, members of the Committee, before I hand over to my colleague and friend Dr. Lunine, I want to stress here to you, to all our elected representatives and leaders, and to the public, that we all need to recognize that the risks of human spaceflight, including the risks to human life, are high, and setbacks are inevitable. Lives are likely to be lost in pursuit of such a tremendous endeavor, and governing statutes will need to recognize that grim fact. And while we recognize that many of our recommendations will be seen by many as "unrealistic" or perhaps even naive, we would observe that, absent changes along the lines we are recommending, the goal of reaching Mars on any meaningful time frame is itself unrealistic.

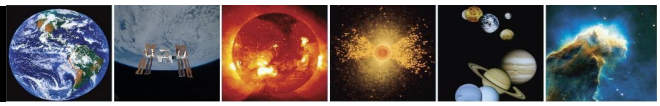
Mr. Chairman, it is my personal hope that that our report will carry the national conversation forward in the direction of realism: realism about public opinion, about risk, about cost, and about the incredibly daunting technical challenges of the horizon goal that we believe the world embraces. Most of all, we hope to foster greater realism about the fact that if we really do want to go to Mars then many actors public and private need to change long-standing behaviors and expectations. We are optimistic the public will support a consensus national goal and we believe the rationales justify its pursuit. We believe the achievement would be monumental if it occurred, but we think there is really one and possibly only one approach to get there, and we've offered up ideas in support of that approach in this report.

**[Dr. Lunine continues]**

As Governor Daniels noted, we would urge members and others to consider—if you cannot read the entire document—to read Chapter 1 of our report, where you will find our major findings and recommendations on issues such as: public and stakeholder opinions about space exploration and human spaceflight in particular; an honest and detailed independent analysis of the technical and affordability realities associated with three possible exploration pathways that lead to Mars; an examination of the rationales for human spaceflight; and most importantly our recommendations on adopting the "pathways approach" we believe will help our nation achieve that next giant leap for humankind.

Let me turn quickly to some of those issues, and Governor Daniels and I would be more than happy to answer any questions members may have following this statement.

Firstly, anyone who reads about the history of space will come quickly to realize that there are many myths that surround both public opinion about human spaceflight, and the proven benefits from human spaceflight. What the committee found was that, if a decision to continue a U.S. human space exploration program were to be based simply on the interests and priorities expressed in public opinion polls taken over the past few decades, it is likely we would not have gone to space. If the decision were based simply on the available data on *proven* benefits that uniquely accrue from a human space exploration, then we would likely not go. However, while the committee felt it was important to examine as closely as possible both public opinion and the historic rationales—and in fact it was charged to do so—we were also aware that such data have numerous limitations and interpretations. We also recognized that by these kinds of criteria alone, we would never have stepped foot on the Moon, yet that achievement is



now viewed as a source of inspiration and great pride by Americans.

In fact, Mr. Chairman, it has been leadership at the national level, at a political level, that determines whether our nation will pursue major new ventures. Our elected leaders have shown courage and vision in the pursuit of human endeavor in space and when those visions are implemented—such as with the Apollo program or the Shuttle program—the public is supportive of our government having spent our tax dollars on what are viewed as endeavors of national importance.

In the end it was the judgment of this diverse committee that the more aspirational rationales, when supplemented by the practical benefits associated with the more pragmatic rationales, do argue for a continuation of the nation's human spaceflight program, provided that certain conditions are met. It is not, however, this committee's opinion that is relevant on this issue. Whether to pursue human exploration beyond low Earth orbit in a truly sustainable way is a decision that deserves careful consideration by our nation's leaders, stakeholders both favorable and opposed, and the public at large. And in making that decision it will be important to ask a question posed many times by us to those provided input to this study, "What would a future be like where there was no expectation that Americans will go into space?"

But as such decisions are contemplated, and as Governor Daniels mentioned, we cannot ignore the significant leaps in technical capability that will be required to land and sustain humans on Mars. Achieving those leaps was the motivation behind our recommended pathways approach since only a sustained program that builds upon a sequence of technical and exploration successes can buy down the risk involved in getting to Mars in any reasonable timeframe. As an example, in one of the possible pathways analyzed in detail in the report, one of the goals or milestones was extended human operations on the lunar surface. I stress extended surface operations—not merely a repeat of an Apollo type landing. Why was this included? Because our technical panel realized—and the committee concurred—that extended surface operations on the Moon would make significant contributions to a strategy ultimately aimed at landing people on Mars by allowing for the development and testing of key operational technologies.

Mr. Chairman, Mars is incredibly hard.

Completing any of the pathways described in our report or indeed any other pathway that is likely to succeed, requires the development of a number of mission elements and technological capabilities and a budgetary support that exceeds growth in purchasing power. The report identifies 10 high-priority capabilities that should be addressed by current research and development activities, with a particular emphasis on Mars entry, descent, and landing, radiation safety, and in-space propulsion and power. These three capabilities will be the most difficult to develop in terms of costs, schedule, technical challenges, and gaps between current and needed abilities. And because the challenges are so great our committee came to the conclusion that our human spaceflight program sits at an important juncture. If there is any significant delay in the United States making a commitment to a truly sustainable program of human spaceflight beyond LEO, we risk a long gap in U.S. human spaceflight activity following the decommissioning of the International Space Station—just as the termination of the Space Shuttle led to a hiatus in U.S. capability to launch astronauts into space. The nation needs to decide now whether it will choose to support a sustained national and international endeavor to pursue exploration beyond low Earth orbit.

If the nation does decide to undertake one of the greatest of human technical endeavors it has ever attempted, we have provided in our report what we call Pathway Principles that could help in the choice of a consensus pathway to that goal. In addition we provide a set of decision rules—guidelines on how to manage the pursuit of the chosen pathway when stressors such as diminished budgets or indeed larger than expected budgets might arise.

Mr. Chairman, our committee is convinced that these principles and decision rules provide a way for our national leadership to decide on a given pathway, measure progress in its pursuit, navigate moving off one pathway to another, or cease the endeavor altogether.

A key element of those principles is that a pathway's chosen set of destinations and stepping stones would generate technical and engineering requirements which as much as possible would feed forward toward the next step and eventually the horizon goal. The committee does not recommend any specific pathway—we were not charged to do so. But we do feel strongly that given the cost of human exploration and the potential cost in human life, only a human presence on another world can justify its pursuit and as we have said previously, Mars is humanity's horizon goal.

To reach that horizon goal will require decades of sustained effort and hundreds of billions of dollars to accomplish. To be a sustainable program, it will require a steadfast national commitment to a consensus goal, international collaboration, and a budget that increases by more than the rate of inflation.

Mr. Chairman, Ms. Johnson, members of the Committee: We are not the first to say that our nation's commitment to human exploration cannot change direction election after election. But in the end our elected leaders are not the impediment to achieving great goals in space, you are the critical enablers of our nation's investment in human spaceflight. Only you can ensure that the leadership, personnel, governance, and resources are in place that will assure human beings will one day walk on the red soil of Mars.

Thank you again for the opportunity to testify today and we remain at your disposal for questions.

**The SSB's sister Board, the Aeronautics and Space Engineering Board, also publishes a newsletter; visit <http://sites.nationalacademies.org/DEPS/ASEB/DEPS_046908> to subscribe or to view past newsletters. SSB's division, the Division on Engineering and Physical Sciences, also publishes a newsletter; visit <http://sites.nationalacademies.org/DEPS/DEPS_059299> to subscribe.**

# SUMMARY OF A CONGRESSIONAL HEARING OF INTEREST

**Committee on Science, Space, and Technology**
**U.S. House of Representatives**
**Full Committee Hearing**
**Pathways to Exploration: A Review of the Future of Human Space Exploration**

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

On June 25, 2014, Dr. Jonathan Lunine and Governor Mitch Daniels, the co-chairs of the Committee on Human Spaceflight presented to the House of Representatives Committee on Science, Space, and Technology the findings of the report *Pathways to Exploration: Rationales and Approaches for a U.S. Program of Human Space Exploration*. The report develops the concept of a "pathways approach" to spaceflight: the basic premise of which is to pick a destination, called a "horizon goal", and then develop a set of possible intermediate missions designed to develop and test technologies that will assist in reaching the horizon goal. However, once selected, the pathway should be pursued in a highly disciplined manner with sustained financial and political support so that intermediate missions contribute toward reaching the horizon goal. This report analyzes three sample pathways to reach the horizon goal of Mars—though the report does not recommend any one pathway.

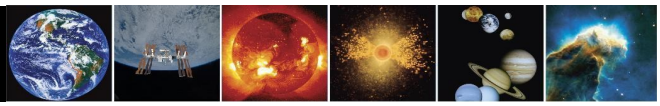
At the beginning of the hearing, Representative Johnson questioned whether human spaceflight, and in particular the journey to Mars, could achieve bipartisan support. Both Dr. Lunine and Governor Daniels believed so, drawing parallels to the authoring committee's own route to consensus. As Governor Daniels reported, the committee, a group purposely composed of members from diverse professions and with a wide range of views on human spaceflight, "became convinced through lengthy discussion and analysis that a combination of what we call the pragmatic and aspirational rationales, including the human impulse to explore and search for new knowledge in places we have never been, justifies the cost, risk and opportunities associated with sending humans beyond low Earth orbit--especially toward the horizon goal we identified as Mars." While no single pragmatic or aspirational rational - such as economic return on investment, science accomplished, or inspiration for future generations - is enough to motivate going to Mars, taken in aggregate, the gathered members of Congress heard that the committee believes that they provide ample justification.

Throughout the hearing, a major theme was that the approach to human spaceflight of "business as usual" will not get humanity to Mars. The longstanding shortcomings this approach included inadequate funding levels for the programs and objectives selected, frequent course changes over multiple administrations and congresses, and a limited level of cost sharing and decision making with international partners.

Multiple representatives asked if NASA's present course was worthwhile. Both Dr. Lunine and Governor Daniels stated that NASA's current capabilities approach, developing technologies and then choosing destinations based on those capabilities, results in technologies that do not all contribute to reaching Mars—what the committee termed "dead end" technologies. While several representatives criticized NASA's Asteroid Redirect Mission (ARM), Dr. Lunine mentioned that one of the three sample pathways includes ARM as a stepping stone to Mars. However, he also noted that the pathway that included ARM had a higher development risk than the other pathways examined.

Some representatives asked the co-chairs if the committee had developed a cost estimate for getting to Mars. In response Dr. Lunine and Governor Daniels noted that while the authoring committee could not produce an exact number, the cost to go to Mars is expected to be on the order of hundreds of billions of dollars spread across multiple decades. They also noted that the committee concluded that the current level of funding for NASA's human spaceflight program would not sustain a program that results in landing humans on Mars. A human spaceflight program with a realistic chance of reaching Mars requires a budget that increase at a rate at least 2-3% higher than that of inflation. Without an increasing budget, the cadence of missions would be slow enough that both interest and experience would be lost between launches. While commitment to fund the project is necessary for its success, the co-chairs noted that the report's decision rules provide for off-ramps to salvage parts of the mission if budgets do decrease while a pathway is being pursued. In response to questions about the role of international cooperation, Governor Daniels and Dr. Lunine advised that although the United States could conceivably cover the whole price tag assuming adequate budget increases, cost-sharing with international partners would save the U.S. money only if those partners were engaged early on and participated in a substantive way at a level not seen heretofore, including the levels seen in the International Space Station partnership.

Throughout the hearing, both Governor Daniels and Dr. Lunine tied many of their answers back to the necessity of choosing a single pathway and pursuing it in a committed way. As Gov. Daniels summarized, a culture of commitment to a pathway was necessary. Without continual work toward a destination, incremental progress would be difficult to maintain; going to Mars requires the unprecedented feat of sustaining interest across decades, administrations, and congresses (and potentially international partners), he stressed. And this new culture and approach would also include the discipline to divest NASA's human spaceflight program of any



*(Continued from page 10)*

architecture and programs that no longer contribute to that program's horizon goal.

Due to the report's emphasis on collaboration with international actors, including potentially China, several representatives questioned the co-chairs about the role international partners should play in human spaceflight missions. Representative Bonamici asked about the differences between NASA's plans and its international partners' plans; NASA's current program is not aligned with its international partner's plans: while many other nations work to reach the lunar surface, NASA currently does not plan to return the moon and instead is focusing on ARM. Governor Daniels replied that while the committee endorses no particular pathway, they note in the report that extended operations on the lunar surface would align the U.S.'s plans with those of its traditional partners and, importantly, allow experience to be gained on a planetary surface-like environment.

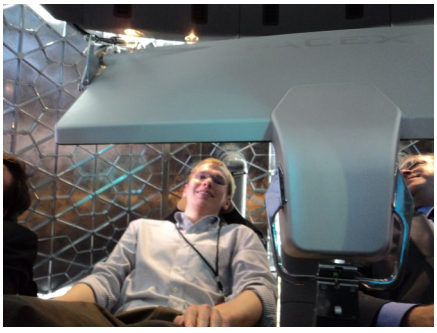
Representatives Rohrabacher and Wilson were both concerned with working with China. Both Dr. Lunine and Governor Daniels agreed that intellectual property protection is a concern, saying that safeguards will need to be developed. However, they both felt that ultimately the cost savings on the program could make cooperation worth the risk. Governor Daniels noted that the U.S. has collaborated on space exploration with countries that it was not on great terms with, such as the Soviet Union. He also mentioned that alliances are likely to shift during the multi-decade course of the project. As the two co-chairs stressed, reaching Mars will be incredibly expensive and requires cost-sharing at previously unseen levels with non-traditional partners. Because inter-governmental collaboration adds complexity, Governor Daniels stated that while the final total cost of the program will likely be higher than if the U.S. pursued the mission by itself, cost-sharing will ultimately make the project much cheaper for the U.S.

Other topics discussed included Congress requiring NASA to develop a roadmap to Mars and working with private partners. Dr. Lunine stated that he believed that defining a pathway would require more detail than is typically expected in a roadmap, as the former would contain decision rules, suggestions on technology that needs to be developed, and more. He believes that if Congress required a roadmap to Mars, it should come from NASA, rather than be prescribed by Congress. Both Governor Daniels and Dr. Lunine also said that private companies will play a role in human spaceflight to Mars, but due to the magnitude of this endeavor, only government actors are likely to have the resources necessary to accomplish such a long-term program.

## *Staff News*

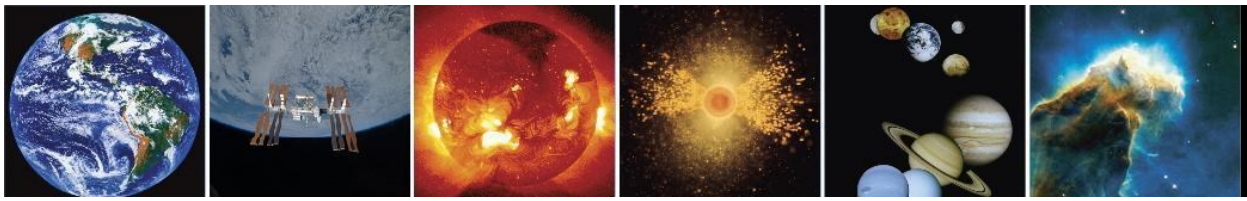
In June the SSB was joined by two new Lloyd V. Berkner Space Policy Interns, Evan Linck and Ian Szumila.

**Evan Linck** is a rising senior at Yale University and a physics major focusing on high-energy particle physics and astrophysics. Throughout his time at Yale, he has conducted research with MicroBooNE at Fermilab in Chicago, IL, and with LUX at Yale in New Haven, CT. In addition to studying physics, Evan has pursued his interests in Chinese language and philosophy while at Yale, including one extended stay in China (and an upcoming one this autumn in Taiwan). After graduation, Evan plans to pursue a doctorate in a still to be decided physics field. Regardless of where his path ultimately leads, he endeavors to raise the general public's science literacy levels, both nationwide and worldwide, by combining his interests in improving STEM education, advocating pragmatic science policy, and enabling greater science outreach.



**Ian Szumila** just completed his studies at Rensselaer Polytechnic Institute, graduating with a double major in physics and geology. He has worked on various research projects at the SETI Institute and his home institution investigating planetary surfaces and the geochemistry of meteorites. This fall, he will start a PhD in geology at the University of Rochester. Spurred by interests in economics and government action, he minored in economics and kept up with policy through extracurricular activities. At the SSB, Ian is getting a chance to experience the intersection of these interests and research passions firsthand through NASA briefings, witnessing testimony on the Hill, meeting the scientists who decide what research measurements are important enough to sustain, as well as those who engage their scientific communities to produce the decadal surveys. By using the knowledge he gains from the Lloyd V. Berkner Space Policy internship, Ian hopes to gain a deep understanding of the science policy that will affect his future area of research.

*Evan Linck (top) and Ian Szumila (bottom) had the opportunity to sit in the SpaceX Dragon capsule at an event held for members of congress and the press on June 10, 2014.*



# SSB Calendar

**July**

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

**August**

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

**September**

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

**October**

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

| | | |
|---|---|---|
| July 2-3 | Space Studies Board Executive Committee | Woods Hole, MA |
| August 25-27 | Committee on Survey of Surveys: Lessons Learned from the Decadal Survey Process | Washington, DC |
| September 3-4 | Committee on Astrobiology and Planetary Science (CAPS) | Irvine, CA |
| September 17-19 | Committee on Earth Science and Applications from Space (CESAS) | Washington, DC |
| October 7-9 | Committee on Solar and Space Physics (CSSP) | Washington, DC |

## Future Meetings of the SSB or its Standing Committees

Committee on Astronomy and Astrophysics (CAA), November 3-4, 2014, Irvine, CA

SSB Fall 2014 Meeting, November 5-6, 2014, Irvine, CA

NRC Space Science Week, March 31-April 2, 2015, Washington, DC

SSB Spring 2015 Meeting – April 22-23, 2015, Washington, DC

SSB Fall 2015 Meeting –November 3-4, 2015, Irvine, CA

SSB Spring 2016 Meeting – April 26-27, 2016, Washington, DC

*Our meeting facilities*

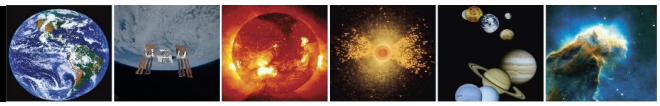
**National Academy of Sciences Building**
**2101 Constitution Ave NW**
**Washington, DC**

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

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

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

WWW.NATIONALACADEMIES.ORG/SSB/



# SELECTED REPORTS AVAILABLE FROM THE SPACE STUDIES BOARD

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

Free PDF versions of all SSB reports
are available online at <http://www.nap.edu>
and on the DVD (listed below)

Hardcopy versions of all SSB reports are available
free of charge from the SSB while supplies last.
To request a hardcopy of a report, send an email to ssb@nas.edu
and include your name, affiliation, mailing address, and
the name and quantity of each report that you are requesting.


- ☐ Pathways to Exploration: Rationales and Approaches for a U.S. Program of Human Space Exploration (2014) CD
- ☐ Evaluation of the Implementation of WFIRST/AFTA in the Context of New Worlds, New Horizons in Astronomy and Astrophysics (2014)
- ☐ Space Studies Board Annual Report 2013 (2014) Book and CD
- ☐ The Space Studies Board 1958-2014: Compilation of Reports (2014) DVD
- ☐ Review of the Draft 2014 Science Mission Directorate Science Plan (2014)
- ☐ Opportunities for High-Power, High-Frequency Transmitters to Advance Ionospheric/Thermospheric Research: Report of a Workshop (2014)
- ☐ Lessons Learned in Decadal Planning in Space Sciences: Summary of a Workshop (2013) Book and CD
- ☐ Landsat and Beyond: Sustaining and Enhancing the Nations Land Imaging Program (2013)
- ☐ Solar and Space Physics: A Science for a Technological Society (2013) Book and CD
- ☐ 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
- ☐ The Role of Life and Physical Sciences (2012) Booklet
- ☐ Earth Science and Applications from Space: A Midterm Assessment of NASA's Implementation of the Decadal Survey (2012) Book and CD
- ☐ Assessment of Planetary Protection Requirements for Spacecraft Missions to Icy Solar System Bodies (2012)
- ☐ Assessment of a Plan for U.S. Participation in Euclid CD Only
- ☐ Technical Evaluation of the NASA Model for Cancer Risk to Astronauts Due to Space Radiation
- ☐ Report of the Panel on Implementing Recommendations from the New Worlds, New Horizons Decadal Survey (2012)
- ☐ Sharing the Adventure with the Public—The Value of Excitement: Summary of a Workshop (2011)
- ☐ Recapturing a Future for Space Exploration: Life and Physical Sciences Research for a New Era (2011) Book and CD
- ☐ Visions and Voyages for Planetary Science in the Decade 2013-2022 (2011) Book and CD
- ☐ Assessment of Impediments to Interagency Collaboration on Space and Earth Science Missions (2011)
- ☐ Forging the Future of Space Science: The Next 50 Years (2010) CD Only
- ☐ Panel Reports—New Worlds, New Horizons in Astronomy and Astrophysics (2011)
- ☐ New Worlds, New Horizons in Astronomy and Astrophysics (2010)
- ☐ Controlling Cost Growth of NASA Earth and Space Science Missions (2010) CD Only
- ☐ Capabilities for the Future: An Assessment of NASA Laboratories for Basic Research (2010) CD Only
- ☐ Revitalizing NASA's Suborbital Program: Advancing Science, Driving Innovation, and Developing a Workforce (2010)
- ☐ Defending Planet Earth: Near-Earth Object Surveys and Hazard Mitigation Strategies (2010) CD Only
- ☐ An Enabling Foundation for NASA's Space and Earth Science Missions (2010)
- ☐ America's Future in Space: Aligning the Civil Space Program with National Needs (2009)
- ☐ Approaches to Future Space Cooperation and Competition in a Globalizing World: Summary of a Workshop (2009)
- ☐ Assessment of Planetary Protection Requirements for Mars Sample Return Missions (2009)
- ☐ Severe Space Weather Events—Understanding Societal and Economic Impacts: A Workshop Report (2008) CD or Executive Summary

If you are unable to email your request, please send a copy of this form to the address or fax number below. Remember to enter the number of reports you wish to receive in the space to the left of each report.

Space Studies Board
The National Academies
500 Fifth Street, NW
Washington, DC 20001
*or fax a copy to: 202-334-3701*

**Name** _____ **E-mail** _____

**Affiliation** _____

**Address** _____ **City/State/Zip** _____