

July—September 2010

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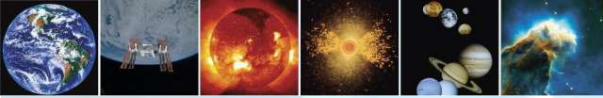


“The SSB has two very important attributes to offer in the conduct of space studies—knowledge and integrity.”

—A. Thomas Young, Vice Chair, SSB

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SPACE STUDIES BOARD NEWS



FROM THE VICE CHAIR



My tenure as a member of the Space Studies Board (SSB) is about to conclude. When I was invited to join the SSB 6 years ago I was honored; I was even more honored when asked to be vice chair. This is an opportunity for me to offer some observations on the Board and the state of the civil space program.

The SSB has two very important attributes to offer in the conduct of space studies—knowledge and integrity. I have been greatly impressed with the extraordinary individuals who are members and even more impressed with the synergy that is represented by the Board as a whole. This remains true as members rotate on and off the Board. However, knowledge alone is not adequate to meet the needs of space studies sponsors. Integrity is another critical ingredient to ensure that SSB reports serve only one master which is in the best interest of the space program. The SSB is truly an “honest broker.” I would be remiss if I did not highlight the exceptional SSB staff that makes the total operation function and makes all of us look good.

Currently, the most significant contributions of the Board are the decadal surveys which define strategies for each element of the U.S. space science program. I have had the privilege to be a member of three decadal surveys. The most frustrating aspect of the surveys is that the list of worthy activities not included in the resulting recommendations greatly exceeds what affordability allows to be included. This is testimony to the quality of the resulting recommended program. My observation is that the members of the decadal surveys treat their responsibilities with the utmost seriousness, and they are dedicated to excellence and maintain uncompromising integrity. The surveys’ outreach, inputs from the community, study, analysis, and debate are comprehensive and most remarkable. The resulting product is clearly the best of the best. We must ensure that the integrity of the decadal surveys is not compromised and continues to represent the “gold standard” in defining the future of space science.

While I am most impressed with the quality of SSB membership and reports, I am disappointed that the full potential of the SSB is not being realized. The policies that govern the operation of the Board can be constraining. The enormous expertise represented by the Board is not being applied to crucial issues, and the loser is the U.S. space program. Hopefully over time a better balance between “rules” and contributions will be achieved.

The state of the U.S. civil space program is mixed. The accomplishments of the science program are incredible and I strongly believe the opportunities available in the next few decades are greater than the extraordinary achievements of the past few decades. For example, the Mars Science Laboratory (MSL) and the James Webb Space Telescope (JWST) have the potential to enormously increase our knowledge of Mars, our solar system, and the universe. However, MSL and JWST cost and schedule issues are present of major credibility challenges. We must do a better job of program management and, in particular, establishing the most probable budgets.

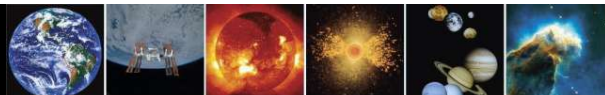
“The SSB is truly an ‘honest broker.’”

Human spaceflight since Apollo has been dominated by the space shuttle and the International Space Station. These are truly remarkable engineering and operations achievements. However, no human space exploration has occurred since Apollo 17, and we have been unable to establish a program that has a sufficient commitment to see it through to implementation. This has resulted in a highly

inefficient use of human exploration resources. Currently there is debate as to what the human exploration program should be. Mars appears to be the consensus ultimate objective. However, the intermediate program is ambiguous. We badly need a high-quality, exciting, and executable program. For too long we have had more program than the budget would support. Either we must have more budget or less program. This is true in the human and robotic programs. Continuing to pursue a program that is not executable will assure another “train wreck.” We will accomplish more with a smaller program that is executable within budget limitations than by pursuing a larger, more attractive program that is not executable within the available budget.

We have had five decades of remarkable accomplishments. The next five decades are populated with challenging and exciting opportunities. To realize this potential, the total space community must be integrated and focused upon the success of the program to provide knowledge, technology, pride, prestige, and inspiration.

—A. Thomas Young, Vice Chair, SSB



DIRECTOR'S CORNER



Friday August 13, 2010 was a major milestone for the SSB and for me personally. Following two years of immense effort by the research community, the latest decadal survey in astronomy and astrophysics was released. The report *New Worlds, New Horizons in Astronomy and Astrophysics* is now available on the National Academies Press website in its prepublication format, as are the reports of the survey's nine expert panels. The reports are free to download from NAP

thanks to the generous support of the Vesto Slipher Fund. The final published, fully edited version of the report will be available in January 2011, with the panel reports in final form shortly thereafter.

Elsewhere in this newsletter, the survey's chair Roger Blandford describes the survey's recommended science program. It is a program that clearly demonstrates the continued vibrancy of this ancient scientific endeavor. It is a program that promises a deeper understanding of the nature of the universe from its earliest moments to the formation of the first stars and galaxies. It is a program that will uncover untold secrets by means of vast surveys of our cosmos—revealing its structure at the largest level and revealing the presence of newly discovered planets in excess of the more than 500 we know of orbiting stars other than our own. It is a program that promises to unlock the mystery of dark energy, an unexpected discovery from the last decade. And it is a program that promises to build on the valuable research infrastructure both in terms of the human resources needed to carry out programs and projects recommended and in terms of the facilities that astronomers use to peer out into the universe.

Before taking over as director of the SSB, I served as the study director for the survey. Although that role entailed long hours, many phone calls, and a virtually never-dormant 24-hour email link to the survey chair, the effort was well worth it when I consider the privilege it has been to work with such a dedicated set of scientists.

I am frequently asked why the astronomy and astrophysics survey has been as successful as it has been over its 50-year history. There are a number of reasons that come to mind, but none are more important than the willingness of the some 200 members of the research community that the NRC appointed to the survey committee, the panels, and the working groups to put aside their own research and spend 2 years working on the prioritization of their field. Equally as important are the many hundreds of astronomers who put an enormous effort into composing more than 700 community-written inputs to the survey. The dedication of the community of astronomers to ensuring a successful survey was palpable over the course of the study, and it continues to be clear at the many town hall meetings that have been held across the country to allow the community to address how to implement the survey's program of science for the next decade and beyond.

The astronomy survey is a fine example, if not one of the premier examples, of why NRC staff do the work they do.

The astronomy survey is a fine example, if not one of the premier examples, of why NRC staff do the work they do. It was an honor to work with such a dedicated team of committee, panel, and working group members. I learned much about the science, the field, and the people of the U.S. astrophysical research enterprise, and this column affords me the opportunity to say thank you to the astronomy and astrophysics community for that experience.

Looking forward to new endeavors, the SSB is preparing for its fall meeting where we will undertake a major workshop that will explore both how the grand questions of the nation's space research program can best convey value and excitement to the public. The workshop will feature invited presentations and session discussions on five "Grand Questions:"

1. Understanding the Universe: How did it begin and how is it evolving?
2. Are we alone?
3. Understanding the Solar System: How did it begin and how is it evolving?
4. Earth: Will it remain a hospitable home for humanity in the future?
5. What could the future hold for humans in space?

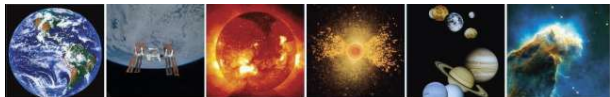
Sessions have been planned that will address issues such as: "Inspiring Public Interest in Space Research and Exploration: Communication Challenges and Opportunities" and "Communication Pathways to the Public: Reading, Watching, Interacting." The workshop will focus on how to sustain public understanding of, interest in, and involvement with NASA science and exploration efforts that

might take several years to decades to unfold. We have more than 200 registrants for the meeting that will be held November 8-10, 2010, at the National Academies' Beckman Center in Irvine, California. A summary report of the workshop will be released in early 2011. More information can be found on the SSB's website. We are grateful to the speakers and panelists who have volunteered to take part in our workshop, and

if you cannot join us in person at the workshop, we urge you to watch for the report's release where we hope to gather the collective wisdom of the participants on this important aspect of our nation's space enterprise.

Finally a regrettable element of the upcoming workshop will be that it is Tom Young's last meeting as vice chair of the Board. While Tom and I have not worked long together on the SSB, in his role as a member of the Astro2010 astronomy and astrophysics decadal survey I have come to welcome and value his sage counsel over the 2 years we have worked on that project. His experience and understanding of the nation's space program is second to none, and while we will miss his serving on the Board, I expect Tom will continue to be an exemplary member of the NRC family through participation in various studies and other activities. All that remains to be done is to thank Tom for the extraordinary service he has provided and continues to provide to the Space Studies Board and the National Academies.

—Michael Moloney, Director, SSB and ASEB



SSB ACTIVITIES

THE BOARD AND ITS STANDING COMMITTEES

The **Space Studies Board (SSB)** did not meet during this quarter; however, the SSB executive committee (XCOM) did meet on August 23-25 at the J. Erik Jonsson Woods Hole Center in Woods Hole, MA, for its annual strategic planning session. The XCOM met with Marc Allen of NASA, and congressional representatives, Dick Obermann and Jeff Bingham. The discussion between XCOM and the government representatives included the impacts of recent reports, future areas of study for the Board, and the role of the Board and standing committees. XCOM members also discussed lessons learned and impacts from the decadal surveys, the midterm assessments of the decadal survey process, and the cost and technical risk assessments that have been done for the recent decadal surveys. The XCOM also discussed potential workshop activities and met with Jean Pierre Swings (European Space Sciences Committee Chair) and Jean-Claude Worms (European Science Foundation) via teleconference for a discussion on a possible ESSC/SSB joint forum series.

The board will meet next at the National Academies' Arnold and Mabel Beckman Center in Irvine, CA, November 8-10, 2010 which will include a workshop on Sharing the Adventure with the Public: The Value and Excitement of "Grand Questions" of Space Science and Exploration. Please visit our website for further details.

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

The **Committee on Earth Studies (CES)** met on July 7-8, 2010, in Washington, DC. Agenda items for this meeting included briefings by NASA, NOAA, and USGS officials on the implementation of the decadal survey in Earth science and applications from space and the implications of a major restructuring of the NPOESS program for climate-related measurements, including continuity of climate data records. As is customary, the committee also met with agency officials to discuss issues of mutual interest, including potential NRC studies or workshops.

A subject of particular interest to the CES is the yet-to-be requested study on the "governance" of Earth observations, which was mandated by the 2005 NASA Authorization Act. In August 2010, members of the CES; NRC staff, including the directors of the SSB and the Board on Atmospheric Sciences and Climate; and representatives from OSTP, USGCRP, and NASA convened by teleconference to discuss prospects for the study, which now appears to be on indefinite hold. SSB staff and members of the committee also met with representatives from the Geography Division of the USGS to discuss a potential study on the value of developing an operational land remote sensing capability. A preliminary statement of task for this study was developed, and revisions were underway as the quarter ended. The SSB is a collaborating NRC unit for the study, "Assessing Requirements for Sustained Ocean Color Research and Operations." During the quarter, members of the CES and SSB staff also were engaged in follow-up activities related to a meeting of the Committee on Assessing Requirements for Sustained Ocean Color Research and Operations on June 28-30 in Irvine, CA.

The **Committee on the Origins and Evolution of Life (COEL)** met last quarter at the National Academies' Keck Center in Wash-

ington, DC, on June 3-4. Discussions at this meeting and recent meetings have led to a study concerning the planetary protection requirements for spacecraft missions to the icy bodies of the outer solar system at the request of NASA. The ad hoc Committee for Planetary Standards for Icy Body Protection in the Outer Planets has been appointed and will begin meeting in January to address their statement of task. For additional information on this project, see the Study Committees section of this newsletter.

The committee will hold their final meeting of 2010, at the National Academies' J. Erik Jonsson Center in Woods Hole, MA on October 13-15. Discussions at this meeting included astrobiology, life on the Titanian ocean, and life in extreme environments.

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

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

STUDY COMMITTEES

As the quarter ended, the report from the ad hoc **Committee on the Assessment of Impediments to Interagency Cooperation on Space and Earth Science Missions** was nearing completion of its response to external review. With the committee's response to review anticipated in mid-October, a prepublication version of the report should be available in November 2010.

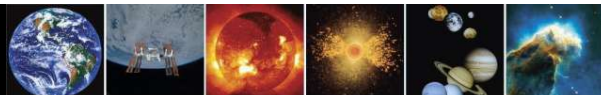
The report of the **Decadal Survey on Astronomy and Astrophysics (Astro2010)** was released as a prepublication on August 13 (the Executive Summary is reproduced in the Reports section on page 8).

The steering committee for the **Decadal Survey on Biological and Physical Sciences in Space** released its interim report to the public on July 14. Co-chairs Betsy Cantwell and Wendy Kohrt briefed NASA and congressional staff (separate briefings). The interim report identified organizational issues important to the success of the life and microgravity research enterprise at NASA, along with areas of near-term research for the International Space Station.

Following the completion of its work on the interim report, the committee returned its full attention to the final report and held its last report development meeting on July 28-30 in Woods Hole. The study panels also worked extensively throughout this period to complete work on issues raised by the steering committee. The completed report draft entered external review on September 16. Review comments were due on October 7, and a subset of the committee met on October 14-15 as part of its activities to address issues raised in review.

The steering committee for the **Decadal Strategy for Solar and Space Physics (Heliophysics)** held its first meeting on September 1-3 at the National Academies' Keck Center in Washington, DC. Work continued on the formation of the three discipline-oriented study panels that will support the steering committee and on the formation of five "national capabilities working groups." These work-

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ing groups are made up of community members who are willing to serve as unpaid consultants to assist the steering committee and panels in gathering information and providing context to the survey's work in particular focus areas. Planning occurred for several town hall events, which will be held in Boulder, CO; Durham, NH; Ann Arbor, MI; College Park, MD; Berkeley, CA; and San Francisco, CA during the fall meeting of the American Geophysical Union. More information about the survey is posted at a public website that is available via a link posted at the homepage of the Space Studies Board (www.nationalacademies.org/ssb); or directly at http://sites.nationalacademies.org/SSB/CurrentProjects/SSB_056864.

The ad hoc **Committee on Planetary Protection Standards for Icy Bodies in the Solar System** was established in September, following formal NRC project approval in July and arrival of NASA funding in August. The study will develop and recommend planetary protection standards for future spacecraft missions, including possible landers and subsurface probes, to the icy bodies in the outer solar system (asteroids, satellites, Kuiper Belt objects, and comets) in light of current scientific understanding and ongoing improvements in mission-enabling capabilities and technologies. The committee will hold its first meeting on January 31-February 2, 2011, at the National Academies' Keck Center in Washington, DC, and its second meeting on March 16-18 at the National Academies' Arnold and Mabel Beckman Center in Irvine, CA.

The **Planetary Science Decadal Survey** charge is to determine the current state of knowledge and identify the most important scientific questions expected to face the community during the interval 2013-2022. During this quarter, the decadal survey's steering committee held its final two meetings in Washington, DC, on July 13-15 and August 3-4. During these two meetings, the steering committee continued its efforts to integrate the panel findings into a final draft report for submission to review. The draft is expected to enter into review in October.

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

OTHER ACTIVITIES

The **Committee on Space Research (COSPAR)** will hold its next scientific assembly in Mysore, India, on July 14-22, 2012. The annual business meetings will be held at COSPAR's Paris headquarters on March 21-24, 2011.

During the next two quarters **SSB outreach staff** will be exhibiting at the American Geophysical Union meeting in December, the American Astronomical Society meeting in January, and the American Association for the Advancement of Science meeting in February.

SSB STANDING COMMITTEE CHAIRS

COMMITTEE ON ASTRONOMY AND ASTROPHYSICS (CAA)*

COMMITTEE ON EARTH STUDIES (CES)

Chair: Berrien Moore III

Vice Chair: Ruth S. DeFries

COMMITTEE ON THE ORIGINS AND EVOLUTION OF LIFE (COEL)**

Co-Chairs: Robert T. Pappalardo and J. Gregory Ferry

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

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

*Joint with the Board on Physics and Astronomy; on hiatus during the Astro2010 decadal survey.

**Joint with the Board on Life Sciences.

***COMPLEX and CSSP are on hiatus during the planetary science decadal survey and the solar and space physics decadal survey, respectively.

SSB MEMBERSHIP

JULY 1, 2010—JUNE 30, 2011

CHARLES F. KENNEL, CHAIR

Scripps Institution of Oceanography,
University of California, San Diego

A. THOMAS YOUNG, VICE CHAIR (12/10)

Lockheed Martin Corporation (ret.)

STEVEN J. BATTEL

Battel Engineering

YVONNE C. BRILL

Aerospace Consultant

ELIZABETH R. CANTWELL

Oak Ridge National Laboratory

ANDREW B. CHRISTENSEN

Dixie State College and
The Aerospace Corporation

ALAN DRESSLER

The Observatories of the Carnegie Institution

JACK D. FELLOWS

University Corporation for Atmospheric
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WARREN M. WASHINGTON

National Center for
Atmospheric Research

CHARLES E. WOODWARD

University of Minnesota

THOMAS H. ZURBUCHEN

University of Michigan

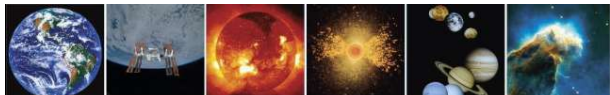
LIAISON

U.S. REPRESENTATIVE TO COSPAR

ROBERT P. LIN

University of California, Berkeley

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



New Worlds, New Horizons in Astronomy and Astrophysics

*By Roger Blandford, Chair, Decadal Survey of Astronomy and Astrophysics and
Donald C. Shapero, Director of the Board on Physics and Astronomy*

Every 10 years the astronomy community mounts a major effort to define a scientific program for the next decade. The surveys build community consensus around a set of priorities for major projects in the field. They have been remarkably successful over the past 50 years in promoting the implementation of these high-priority initiatives on the ground and in space.

The current survey, organized under the auspices of the Board on Physics and Astronomy and the Space Studies Board of the National Research Council, was recently released in preliminary form (National Research Council, 2010). Following in the footsteps of its five predecessors, it recommends a prioritized program of activities for the 2012-2021 decade, and it lays the foundation for the decade after that. But unlike previous surveys, it reprioritized any project recommended in a previous survey that has not been realized. And, responding to concerns about cost growth of major projects, the survey engaged the Aerospace Corporation to assist it in assessing the technical readiness and appraising the likely cost of the large projects. The recommended program fits within plausible budget scenarios based on input from the agencies supporting research in this field. As a result, recommended priorities reflect an executable balance of scientific promise against cost, risk, and readiness. The international context also played an important role in the committee's deliberations, and many of the large projects involve international collaboration as well as private donors and foundations.

An important feature of the surveys is extensive consultation with and input from the scientific community. To plan the survey and assist in making the decision about when to initiate it, the Board on Physics and Astronomy convened a group of researchers at the National Academies' Keck Center. The result was the foundation of a proposal to NASA, NSF, and DOE to launch a new survey, dubbed Astro2010. The survey committee, formed in 2008, created 9 panels involving 123 members of the astronomy and astrophysics research community at universities and government laboratories to provide science assessments and to establish priorities within defined areas of ground-based and space-based research. The Committee issued a request for information to elicit proposals for projects to be prioritized, which resulted in the submission of more than 300 white papers that provided broad community input to the panels. More details on the process may be found at <http://www.nationalacademies.org/bpa>.

The committee found that astronomers' overall view of the universe has changed dramatically in the past decade. Hundreds of planets of startling diversity have been discovered orbiting distant suns. Black holes, once viewed as an exotic theoretical possibility, are now known to be present at the center of most galaxies, including our own. Precision measurements of the primordial radiation left by the big bang have enabled astronomers to determine the age, size, and shape of the universe. Other astronomical observations have revealed that most of the matter in the universe is dark and invisible, and the expansion of the universe is accelerating in an unexpected and unexplained way. Recent discoveries, powerful new ways to observe the universe, and bold new ideas to understand it have cre-



The Astronomy and Astrophysics Survey Committee

ated scientific opportunities without precedent.

The growing intersection between physics and astronomy figures prominently in the new discoveries and insights about the universe. The physics underlying many astronomical phenomena is becoming clearer. At the same time, the cosmos is proving to be a laboratory for the exploration of basic questions in general relativity, particle and nuclear physics, and atomic, condensed-matter, and plasma physics.

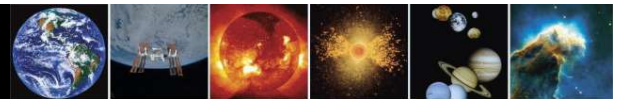
The science objectives chosen by the survey committee for the decade 2012-2021 are

- Searching for the first stars, galaxies, and black holes;
- Seeking nearby habitable planets; and
- Advancing understanding of the fundamental physics of the universe.

These three objectives represent unprecedented opportunities that are now becoming within our capability to explore. The discoveries made will surely lead to new and sometimes surprising insights that will continue to expand our understanding and sense of possibility, revealing new worlds and presenting new horizons, the study of which will bring us closer to understanding the cosmos and our place within it. The identification of these science priorities played a seminal role in the process: the organizing principle for construction of the project priorities was to provide a balanced portfolio of capabilities to address these science objectives.

This report recommends a program that will set the astronomy and astrophysics community firmly on the path to answering some of the most profound questions about the cosmos. In the plan, new optical and infrared survey telescopes on the ground and in space will employ a variety of novel techniques to investigate the nature of dark energy. These same telescopes will determine the architectures of

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thousands of planetary systems, observe the explosive demise of stars, and open a new window on the time-variable universe. Spectroscopic and high-spatial-resolution imaging capabilities on new, large ground-based telescopes will enable researchers to discern the physical nature of objects discovered at both shorter and longer wavelengths by other facilities in the committee's recommended program. Innovative moderate-cost programs in space and on the ground will be enhanced so as to enable the community to respond rapidly and flexibly to new scientific discoveries. Construction will begin on a space-based observatory that employs the new window of gravitational radiation to observe the merging of distant black holes and other dense objects and to precisely test theories of gravity in new regimes that we can never hope to study on Earth. The foundations will be laid for studies of the hot universe with a future X-ray telescope that will search for the first massive black holes and follow the cycling of gas within and beyond galaxies. Scientists will conduct new ground-based experiments to study the highest-energy photons emitted by cosmic sources. At the opposite end of the electromagnetic spectrum, radio techniques will become powerful enough to view the epoch when the very first objects began to light up the universe, marking the transition from a protracted dark age to one of self-luminous stars. The microwave background radiation will be scrutinized for the telltale evidence that inflation actually occurred. Perhaps most exciting of all, researchers will identify which nearby stars are orbited by planets on which life could also have developed.

Realizing these and an array of other scientific opportunities is contingent on maintaining and strengthening the foundations of the research enterprise that are essential in the cycle of discovery—including technology development, theory, computation and data management, and laboratory experiments, as well as, and in particular, human resources. At the same time, the greatest strides in understanding often come from bold new projects that open the universe to new discoveries, and such projects thus drive much of the strategy of the survey's proposed program. This program requires a balance of small, medium, and large initiatives on the ground and in space. The large and medium elements within each size category are as follows:

In Space: (Large-scale, in priority order) *Wide-Field Infrared Survey Telescope* (WFIRST)—an observatory designed to settle essential questions in both exoplanet and dark energy research, and which will advance topics ranging from galaxy evolution to the study of objects within our own galaxy. *The Explorer Program*—augmenting a program that delivers a high level of scientific return on relatively moderate investment and that provides the capability to respond rapidly to new scientific and technical breakthroughs. *Laser Interferometer Space Antenna* (LISA)—a low-frequency gravitational wave observatory that will open an entirely new window on the cosmos by measuring ripples in space-time caused by many new sources, including nearby white dwarf stars, and will probe the nature of black holes. *International X-ray Observatory* (IXO)—a powerful X-ray telescope that will transform our understanding of hot gas associated with stars and galaxies in all evolutionary stages.

(Medium-scale, in rank order) *New Worlds Technology Development Program*—a competed program to lay the technical and scientific foundation for a future mission to study nearby Earth-like planets. *Inflation Probe Technology Development Program*—a competed program to prepare for a potential next-decade cosmic microwave-background mission to study the epoch of inflation.

On the Ground: (Large-scale, in priority order) *Large Synoptic Survey Telescope* (LSST)—a wide-field optical survey telescope that will transform observation of the variable universe and will address broad questions that range from indicating the nature of dark energy to determining whether there are objects that may collide with Earth. *Mid-Scale Innovations Program augmentation*—a competed program that will provide the capability to respond rapidly to scientific discovery and technical advances with new telescopes and instruments. *Giant Segmented Mirror Telescope* (GSMT)—a large optical and near-infrared telescope that will revolutionize astronomy and provide a spectroscopic complement to the James Webb Space Telescope (JWST), the Atacama Large Millimeter Array (ALMA), and LSST. *Atmospheric Cerenkov Telescope Array* (ACTA)—participation in an international telescope to study very high energy gamma rays. (Medium-scale) *CCAT* (formerly the Cerro Chajnantor Atacama Telescope)—a 25-meter wide-field submillimeter telescope that will complement ALMA by undertaking large-scale surveys of dust-enshrouded objects.

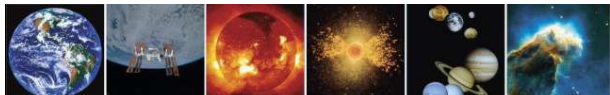
These major new elements must be combined with ongoing support of the core research program to ensure a balanced program that optimizes overall scientific return. To achieve that return, the survey balances the program with a portfolio of unranked smaller projects and augmentations to the core research program, funded by all three agencies. These elements include support of individual investigators, instrumentation, laboratory astrophysics, public access to privately operated telescopes, suborbital space missions, technology development, theoretical investigations, and collaboration on international projects.

The survey report also identifies unique ways that astronomers can contribute to solving the nation's challenges. In addition, the public will continue to be inspired with images of the cosmos and descriptions of its contents, and students of all ages will be engaged by vivid illustrations of the power of science and technology. These investments will sustain and improve the broad scientific literacy vital to a technologically advanced nation, as well as providing spin-off technological applications to society.

The committee and I are deeply grateful to the astronomy and astrophysics community for its commitment to this gigantic effort and its broad involvement, as well as a willingness to support the community consensus. That support was essential to producing the report, and it will continue to be essential in implementing the shared vision that the survey report recommends.

National Research Council. *New Worlds, New Horizons in Astronomy and Astrophysics*. Washington, DC: The National Academies Press, 2010 (prepublication version).

This article appeared in the APS News (<http://www.aps.org/publications/apsnews/>) November 2010 (Volume 19, Number 10).



NEW RELEASES FROM THE SSB

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



New Worlds, New Horizons in Astronomy and Astrophysics

This report by the Committee for a Decadal Survey of Astronomy and Astrophysics is available at http://www.nap.edu/catalog.php?record_id=12951. The study was led by Roger Blandford, Chair; Vice Chairs, Martha Haynes, John Huchra, and Marcia Rieke; and Executive Officer Lynne Hillenbrand. The study was staffed by Michael Moloney, Study Director (see pages v-ix of the report for a full staff listing). This study was led by the Board on Physics and Astronomy in conjunction with the Space Studies Board.

Executive Summary

Our view of the universe has changed dramatically. Hundreds of planets of startling diversity have been discovered orbiting distant suns. Black holes, once viewed as an exotic theoretical possibility, are now known to be present at the center of most galaxies, including our own. Precision measurements of the primordial radiation left by the big bang have enabled astronomers to determine the age, size, and shape of the universe. Other astronomical observations have also revealed that most of the matter in the universe is dark and invisible and that the expansion of the universe is accelerating in an unexpected and unexplained way. Recent discoveries, powerful new ways to observe the universe, and bold new ideas to understand it have created scientific opportunities without precedent.

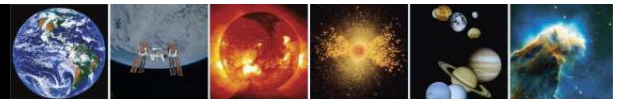
This report of the Committee for a Decadal Survey of Astronomy and Astrophysics proposes a broad-based, integrated plan for space- and ground-based astronomy and astrophysics for the decade 2012–2021. It also lays the foundations for advances in the decade 2022–2031. It is the sixth in a sequence of National Research Council (NRC) decadal studies in this field and builds on the recommendations of its predecessors. However, unlike previous surveys, it reexamines unrealized priorities of preceding surveys and reconsiders them along with new proposed research activities to achieve a revitalized and timely scientific program. Another new feature of the current survey is a detailed analysis of the technical readiness and the cost risk of activities considered for prioritization. The committee has formulated a coherent program that fits within plausible funding profiles considering several different budget scenarios based on briefings by the sponsoring agencies—the National Aeronautics and Space Administration, the National Science Foundation, and the Department of Energy. As a result, recommended priorities reflect an executable balance of scientific promise against cost, risk, and readiness. The international context also played an important role in the committee's deliberations, and many of the large projects involve international collaboration as well as private donors and foundations.

The priority science objectives chosen by the survey committee for the decade 2012–2021 are searching for the first stars, galaxies, and black holes; seeking nearby habitable planets; and advancing understanding of the fundamental physics of the universe. These three objectives represent unprecedented opportunities now becoming within our capability to explore. The discoveries made will surely lead to new and sometimes surprising insights that will continue to expand our understanding and sense of possibility, revealing new worlds and presenting new horizons, the study of which will bring us closer to understanding the cosmos and our place within it.

This report recommends a program that will set the astronomy and astrophysics community firmly on the path to answering some of the most profound questions about the cosmos. In the plan, new optical and infrared survey telescopes on the ground and in space will employ a variety of novel techniques to investigate the nature of dark energy. These same telescopes will determine the architectures of thousands of planetary systems, observe the explosive demise of stars, and open a new window on the time-variable universe. Spectroscopic and high-spatial-resolution imaging capabilities on new large ground-based telescopes will enable researchers to discern the physical nature of objects discovered at both shorter and longer wavelengths by other facilities in the committee's recommended program. Innovative moderate-cost programs in space and on the ground will be enhanced so as to enable the community to respond rapidly and flexibly to new scientific discoveries. Construction will begin on a space-based observatory that employs the new window of gravitational radiation to observe the merging of distant black holes and other dense objects and to precisely test theories of gravity in new regimes that we can never hope to study on Earth. The foundations will be laid for studies of the hot universe with a future X-ray telescope that will search for the first massive black holes, and that will follow the cycling of gas within and beyond galaxies. Scientists will conduct new ground-based experiments to study the highest-energy photons emitted by cosmic sources. At the opposite end of the electromagnetic spectrum, radio techniques will become powerful enough to view the epoch when the very first objects began to light up the universe, marking the transition from a protracted dark age to one of self-luminous stars. The microwave background radiation will be scrutinized for the telltale evidence that inflation actually occurred. Perhaps most exciting of all, researchers will identify which nearby stars are orbited by planets on which life could also have developed.

Realizing these and an array of other scientific opportunities is contingent on maintaining and strengthening the foundations of the research enterprise that are essential in the cycle of discovery—including technology development, theory, computation and data management, and laboratory experiments, as well as, and in particular, human resources. At the same time, the greatest strides in understanding often come from bold new projects that open the universe to new discoveries, and such projects thus drive much of the strategy of the committee's proposed program. This program requires a balance of small, medium, and large initiatives on the ground and in space. The large and medium elements within each size category are as

(Continued on page 9)



(New Releases continued from page 8)

follows:

In Space: (Large-scale, in priority order) *Wide-Field Infrared Survey Telescope (WFIRST)*—an observatory designed to settle essential questions in both exoplanet and dark energy research, and which will advance topics ranging from galaxy evolution to the study of objects within our own galaxy. *The Explorer Program*—augmenting a program that delivers a high level of scientific return on relatively moderate investment and that provides the capability to respond rapidly to new scientific and technical breakthroughs. *Laser Interferometer Space Antenna (LISA)*—a low-frequency gravitational wave observatory that will open an entirely new window on the cosmos by measuring ripples in space-time caused by many new sources, including nearby white dwarf stars, and will probe the nature of black holes. *International X-ray Observatory (IXO)*—a powerful X-ray telescope that will transform our understanding of hot gas associated with stars and galaxies in all evolutionary stages. (Medium-scale, in rank order) *New Worlds Technology Development Program*—a competed program to lay the technical and scientific foundation for a future mission to study nearby Earth-like planets. *Inflation Probe Technology Development Program*—a competed program designed to prepare for a potential next-decade cosmic microwave-background mission to study the epoch of inflation.

On the Ground: (Large-scale, in priority order) *Large Synoptic Survey Telescope (LSST)*—a wide-field optical survey telescope that will transform observation of the variable universe and will address broad questions that range from indicating the nature of dark energy to determining whether there are objects that may collide with Earth. *Mid-Scale Innovations Program augmentation*—a competed program that will provide the capability to respond rapidly to scientific discovery and technical advances with new telescopes and instruments. *Giant Segmented Mirror Telescope (GSMT)*—a large optical and near-

infrared telescope that will revolutionize astronomy and provide a spectroscopic complement to the James Webb Space Telescope (JWST), the Atacama Large Millimeter Array (ALMA), and LSST. *Atmospheric Čerenkov Telescope Array (ACTA)*—participation in an international telescope to study very high energy gamma rays. (Medium-scale) *Cerro Chajnantor Atacama Telescope (CCAT)*—a 25-meter wide-field submillimeter telescope that will complement ALMA by undertaking large-scale surveys of dust-enshrouded objects.

These major new elements must be combined with ongoing support of the core research program, to ensure in a balanced program that optimizes overall scientific return. To achieve that return the committee balances the program with a portfolio of unranked smaller projects and augmentations to the core research program, funded by all three agencies. These elements include support of individual investigators, instrumentation, laboratory astrophysics, public access to privately operated telescopes, suborbital space missions, technology development, theoretical investigations, and collaboration on international projects.

This report also identifies unique ways that astronomers can contribute to solving the nation’s challenges. In addition, the public will continue to be inspired with images of the cosmos and descriptions of its contents, and students of all ages will be engaged by vivid illustrations of the power of science and technology. These investments will sustain and improve the broad scientific literacy vital to a technologically advanced nation as well as providing spin-off technological applications to society.

The committee notes with appreciation the striking level of effort and involvement in this survey contributed by the astronomy and astrophysics community. The vision detailed in this report is a shared vision.

LLOYD V. BERKNER SPACE POLICY INTERNSHIPS

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

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

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

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

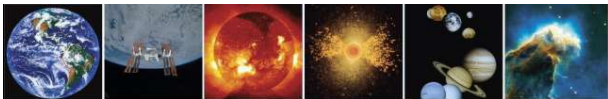
The SSB is now accepting applications from undergraduates for its summer 2011 program. The deadline for applications is February 4, 2011. Successful candidates will be contacted no later than March 4, 2011.

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

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

NOTE: SELECTION OF 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.



SSB Research Associate Presents at the 61st International Astronautical Congress



by Lewis Groswald, SSB Research Associate

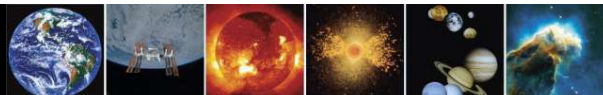
Every year, the [International Astronautical Federation \(IAF\)](#) holds a conference where people from all over the world convene to present, discuss, and learn about the latest in space science, engineering, technology development, and policy around the world. The conference takes place in a different city each year, and this year's [61st International Astronautical Congress \(IAC\)](#) was based in Prague, Czech Republic. Topics addressed at the congress included space life sciences, microgravity sciences and processes, solar system exploration (human and robotic), space debris, Earth observation, space communications and navigation, small satellite missions, astrodynamics, materials and structure, space power and propulsion, space history, education, visions and strategies, space transportation, business, and space law. I was fortunate enough to present a paper written by me and two of my classmates from the George Washington University Space Policy Institute graduate program on a new type of small satellite, the CubeSat.

The focus of our paper was two-fold: explaining how cubesats fit in the Organization for Economic Cooperation and Development's (OECD's) Science, Technology, and Industry Scorecard; and showing that cubesats can be a low-cost/low barrier to entry beginning, or at least a viable part, of a knowledge-based economy, especially for developing nations. This scorecard, with 57 indicators, is designed to help policymakers determine what actions they can take (or are already taking) to transform their economy towards a knowledge-based one. The paper was broken down into three pillars (science, technology, engineering and mathematics education; science; and innovation) to elucidate the capabilities of cubesats in these areas and to show how these three areas fit within the larger OECD Scorecard. An example of our mapping exercise is shown to the right.

Of course, we recognized that this nascent technology, which only just came into being in 2000 from Caltech, is not a panacea for the woes of the large and expensive satellite systems, and so far it is still limited in its capabilities. However, even over the past decade, the cubesat has been improved upon and its capabilities expanded to include remote sensing and biological experiments in microgravity. Moreover, the relative low cost—anywhere from a few tens of thousands of dollars to \$1 million—and low barrier to entry for the technology make it a promising avenue for building up an aerospace cadre in a developing nation. Nevertheless, these sums are still not very modest for a university that operates on a budget considerably smaller than, say NASA. Consequently, we recommended that universities and governments around the world work together to figure out ways to provide adequate and stable funding for these programs and incubate the next generation of aerospace engineers and scientists.

Finally, I would be remiss if I did not talk a little bit about the host city, Prague. I conducted my undergraduate study-abroad semester in Prague, so returning to what I, very subjectively, consider to be the most beautiful city in Europe and a former home was quite a treat. I found it interesting that the 28th IAC was held in Prague in 1977, and while the city has undoubtedly changed since then, little if anything appears different since I lived there 3 years ago. I highly recommend visiting Prague, where residents highly cherish their history but, at the same time, pride themselves on shrugging off their Cold War past and moving into the future. Did you know that the Czech Republic has its own [Czech Space Office](#)?

	STEM Education	Science	Innovation
OECD Investing in the Knowledge Economy relation to cubesats			
New University graduates	x		
New Doctoral graduates	x		
Human resources in science and technology	x		
Tertiary level graduates employed	x		
OECD Connecting to Global Research relation to cubesats			
International cooperation in research	x	x	x
International cooperation in science		x	
International collaboration on innovation			x
OECD Competing in the World Econ. relation to cubesats			
International trade			x
International trade in ICT goods and services			x
Electronic commerce			x
Non-technological innovation			x
Product and market innovation using trademarks			x
Internet access and use by businesses			x
Entrepreneurship			x
OECD Targeting New Growth Areas relation to cubesats			
Environmental sciences	x	x	x
Telecommunication networks			x
Health-related R&D		x	
Biotechnology R&D		x	
Biosciences		x	
Government R&D budgets	x	x	x
Public-private cross-funding of R&D	x	x	x
Collaboration by innovating firms			x
OECD Responding to the Economic Crisis relation to cubesats			
Venture capital in the economic crisis			x
R&D in the econ. crisis	x	x	x
Patent intensity over the business cycle			x



STAFF NEWS

Lloyd V. Berkner Space Policy Internship

During this quarter the Lloyd V. Berkner Space Policy Internship Program welcomed Gabriele Betancourt Martinez (Yale University) and Jason Callahan (George Washington University) as participants in its 2010 autumn program and said good-bye to our 2010 summer interns, Dara Fisher and Andreas Frick.

The goal of the program is to provide promising students with the opportunity to work in the area of civil space-research policy in the nation's capital, under the aegis of the SSB. Additional information on the program can be found in this newsletter and at http://sites.nationalacademies.org/SSB/ssb_052239.

Gabriele Betancourt-Martinez graduated in May of 2010 from Yale University with a B.S. in astronomy and physics. Her senior project involved optimizing the circuitry for the photomultiplier tube array in PIXeY (Particle Identification in Xenon at Yale), a small-scale, liquid xenon dark matter detector. She also investigated the kinematics and evolution of multiple star-forming dense cores in the radio band through the Yale STARS II fellowship. She is greatly enjoying exploring the realm of space policy as a way of combining her love of practicing science with increased interaction with the public, and suspects that she will return to the field at some point in her career. When not working, Gabriele spends her time dancing, riding horses, traveling, and indulging in her foodie tendencies. She will begin a Ph.D. program in astronomy at the University of Maryland, College Park, in fall 2011.

Jason Callahan is in the second year of the master's degree program in International Science and Technology Policy at George Washington University's Space Policy Institute, where he also works as a research assistant. He received his bachelor's degree from the University of Florida in history of science, and a master's degree from the Georgia Institute of Technology in history and sociology of science and technology. Jason spent the summer working as an intern for the Tauri Group.

Dara Fisher completed her assignment with the SSB as a Summer 2010 Lloyd V. Berkner Space Policy Intern in August. Her reflections on her experience with the SSB appear below.

When I first received an offer from the Space Studies Board for a Berkner internship in the summer of 2010, I was absolutely thrilled. When I had first read about the program

midway through my junior year, I thought that it perfectly balanced my academic interests—space science, communications, and the world of public policy. In my 10 weeks spent in Washington, all of my hopes for this internship have been realized, and I am returning to school with more real-world knowledge than I ever imagined.

During my time with the SSB, I participated in an extremely diverse set of activities, including contributing to four different decadal surveys, writing report briefs for five NRC publications, and attending meetings for both standing committees and the Steering Committee of the Planetary Science Decadal Survey. Additionally, I was able to attend many space-related events and receptions around Washington, DC, including several events on Capitol Hill and an NRC report briefing to Senator Bill Nelson (D-FL).

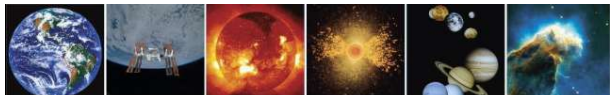
I have gained so much valuable experience during my time here, and this opportunity has helped me to decide that a future in national science policy is the right career choice for me. I look forward to continuing down this path after I graduate next spring, and I have the SSB and Aeronautics and Space Engineering Board staff to thank for this decision. I hope that we will stay in touch and I will see you all upon my return to Washington!

Andreas Frick completed his assignment with the SSB as a Summer 2010 Lloyd V. Berkner Space Policy Intern in August. His reflections on his experience with the SSB appear below.

If there is one emblematic question during the final years of my undergraduate life as a double-major in aerospace engineering and political science, it would be “And what are you going to do with that?” To be honest, I wasn't quite sure at the time if there was any single, concise, and honest answer to that question. I had been weighing various career options, graduate programs, and internships, but none of them seemed to combine my interests as convincingly as the Berkner internship. Needless to say, I was delighted to accept.

Within the first week of my internship, my desk became populated with various policy studies and space mission concepts relating to the ongoing Planetary Science Decadal Survey—which would become the framework for the majority of my tasks during the internship. Despite my high expectations, the depth and breadth of the projects I was involved with was far beyond what I had imagined. Also within the first week, I had the pleasure to attend a space and national security policy roundtable at the National Press Club, as well as a House Science and Technology Committee hearing featuring astronauts Neil Armstrong and Gene Cernan, former Lockheed vice

(Continued on page 12)



(Continued from page 11)

president Tom Young (who I'd become more acquainted with at various SSB activities), and NASA Administrator Charlie Bolden. This was just the beginning of many out-of-office meetings organized by the SSB for the benefit of acquainting the interns with the "who's who" of space policy. Many of them had been involved with the SSB in some capacity. I was in good company.

Furthermore, I contributed to the heliophysics and the biological and physical science in space decadal surveys, helped to prepare a study briefing for an ASEB study, contributed to the SSB annual report, as well as several other tasks and activities. In the process, I would often find myself in a room with some of the world's most renowned experts in their fields.

And yet, I still don't have a short answer to the question of how to consolidate a background in aerospace engineering and political science. If anything, the Berkner internship has taught me how complex and profound these interactions really are—far beyond any "simple answer." I am now pursuing an M.A. in international science and technology policy at George Washington University, with a focus in space policy. I am extremely grateful to everyone at the SSB for helping augment my scientific and technological understanding with broad, program-level analysis and public policy. I am confident our paths will cross again during my time in Washington, DC and beyond.

Christine Mirzayan Science and Technology Policy Graduate Fellowship Program

We are also happy to welcome Bruno Sánchez-Andrade Nuño as the SSB's Fall 2010 Mirzayan Fellow. 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 about the fellows program can be found at <http://sites.nationalacademies.org/PGA/policyfellows/index.htm>.

Bruno Sánchez-Andrade Nuño has worked since 2008 as a space and rocket scientist at the Naval Research Laboratory in Washington, DC. He is a faculty member at George Mason University. In 2008 he obtained his Ph.D. in astrophysics at the Max Planck Institute for Solar System Research in Goettingen, Germany. Both his current work and Ph.D. have focused on understanding the Sun and the Sun-Earth relation, including space weather. In the past 7 years, he has also devoted much of his free time to science outreach in several countries with articles, webpages, workshops and conferences. He has a strong passion for science and technology and its practical applications for a better world and the understating of this increasing potential by the society. This professional drive, and his will to benefit the society at large has lead Bruno to pursue a career in science policy. As a Mirzayan fellow, he is excited to engage the complicated world of science advice and policy. Originally from a small village in Asturias, Spain, he tries to keep up a balanced life of running, reading, climbing, and getting to know other cultures as much as possible.

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Lloyd V. Berkner Space Policy Interns

Autumn 2010

GABRIELE BETANCOURT-MARTINEZ

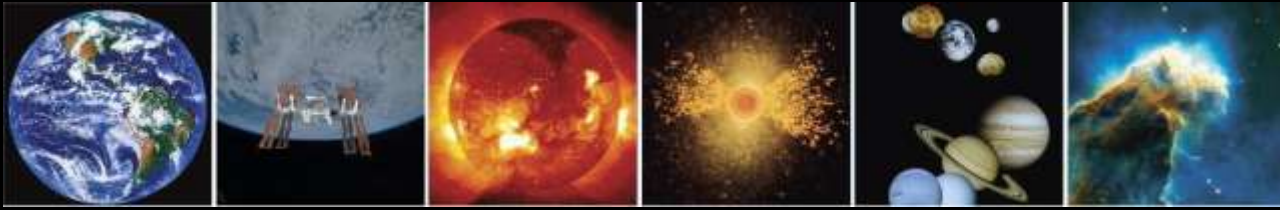
JASON CALLAHAN

Summer 2010

DARA FISHER

ANDREAS FRICK

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



SSB Calendar

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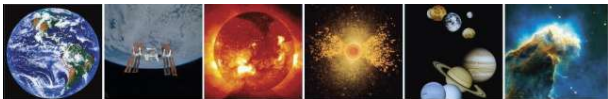
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- October 13-15 *Committee on Origins and Evolution of Life (COEL)—Woods Hole, MA*
- November 8-10 *Space Studies Board (SSB) and Workshop on Sharing the Adventure with the Public: The Value and Excitement of "Grand Questions" of Space Science and Exploration—Irvine, CA*
- November 15-17 *Decadal Survey on Solar and Space Physics (Heliophysics): Panel on Atmosphere-Ionosphere-Magnetosphere Interactions—Boulder, CO*
- November 17-19 *Decadal Survey on Solar and Space Physics (Heliophysics): Solar Wind-Magnetosphere Interactions—Boulder, CO*
- November 29-December 1 *Decadal Survey on Solar and Space Physics (Heliophysics): Panel on Solar and Heliospheric Physics—Washington, DC*
- January 31-February 2 *Committee on Planetary Protection Standards for Icy Bodies in the Solar System—Washington DC*

Future ssb Meetings

- April 6-8, 2011, in Washington, DC
(April 6 is a joint session with the ASEB)
- November 8-10, 2011, in Irvine, CA
- April 4-6, 2012, in Washington, DC
(April 4 is a joint session with the ASEB)
- November 5-7, 2012, Irvine, CA



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- Satellite Observations to Benefit Science and Society: Recommended Missions for the Next Decade (2008) Booklet
- Ensuring the Climate Record from the NPOESS and GOES-R Spacecraft: Elements of a Strategy to Recover Measurement Capabilities Lost in Program Restructuring (2008)
- Opening New Frontiers in Space: Choices for the Next New Frontiers Announcement of Opportunity (2008)
- Space Studies Board Annual Report 2007 (2008)
- Space Science and the International Traffic in Arms Regulations: Summary of a Workshop (2008)
- Assessment of the NASA Astrobiology Institute (2008)
- Grading NASA's Solar System Exploration Program: A Midterm Review (2008)
- NASA's Beyond Einstein Program: An Architecture for Implementation (2007)
- The Limits of Organic Life in Planetary Systems (2007)

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