This is my final quarterly column as Chair of the Space Studies Board. My service, after five years, ended on June 30. For me, being Chair of the SSB has been the highlight of my career. The times have been challenging but extremely interesting. The influence of the Board has never been greater or more important. I am grateful to the two Directors of the Board with whom I served: my long-standing friend Joe Alexander and my new friend Marcia Smith. Each of them, and the staff that they have led, has made the success we have enjoyed possible. And then of course there are the many scientists, engineers, and policy experts who have served on the Board and its many committees. Collectively, they produced nearly 50 reports on a broad range of topics, from a decadal survey for Earth science, to a report on the repair of the Hubble Space Telescope, to a study of weird life elsewhere in the universe, to a study of the NASA workforce. The time contributed to these reports was all freely given. It is greatly appreciated and essential to the success of the space program.

I am also very pleased that Charlie Kennel is my successor. It is difficult to imagine anyone more qualified to be Chair of the SSB than Charlie. His own science discipline is space plasma physics. He has directed Earth science both at NASA and at the Scripps Institute of Oceanography. He has chaired countless NRC studies, including the recent astrophysical study on the Beyond Einstein missions. Charlie is familiar with the ways of Washington and of academia. I am certain that he will use wisely and effectively the great bully pulpit for space science that the chairmanship of the SSB provides.

This was a wonderful year in which to end my chairmanship of the SSB. We have had a year-long celebration of the 50th anniversary of the seminal events that launched the space age: the International Geophysical Year and the launches of Sputnik and Explorer 1; the Space Act and the formation of NASA; and the establishment of the Space Studies Board. It is remarkable how quickly events unfolded at the beginning of the space age, how soon the institutions on which we have depended came into existence, and how effectively they have functioned ever since.

This is also the 50th anniversary of the establishment of COSPAR, the Committee on Space Research, which has as its function to promote international cooperation in space science. I have been asked to deliver a keynote speech at the upcoming COSPAR General Assembly in Montreal on the wonderfully broad topic, “The Impact of Space on Society.” The preparation for this talk has caused me to marvel on how profound and how deep the impact of space has been, and to recognize how much more impact is possible.

We live in a global, highly interdependent world. Trade is global, our industrial base is global, we are knowledgeable of what is happening in the world at all places and at all times. So much of this has been made possible by the space age: satellite communications, remote sensing, direct broadcast, and GPS, to cite just a few. And from this globalization has come a degree of stability. It is difficult to imagine a confrontation among nations whose economies are thoroughly intertwined.

Space has also profoundly altered our sense of our place in the universe. For some of
us, it was the Apollo 8 picture of the beautiful but fragile Earth in the black sea of space. For others it was Voyager’s picture of the planets as it left the solar system, revealing small and insignificant objects. And then there has been the steady drumbeat of planetary and astrophysical observations that reveal the majesty and the unfathomable vastness of the universe. We are in the midst of a second Copernican-type revolution; the first of which displaced us from the center of the universe to just another planet around the Sun. As the true vastness of the universe becomes known and appreciated by all and as we realize how common are our planetary circumstances, we become evermore aware of our insignificance. Perhaps we will view our insignificance in a positive light—that our tensions and conflicts—our constant, everyday concerns—are truly insignificant in the grand scheme of the cosmos.

The space programs of the world, however, are an underutilized resource. The U.S. space program was sized during Apollo to be supported by 4 percent of the federal budget, yet today NASA receives less than 0.7 percent. Other nations have developed capable space programs, and they too could do more if they were asked to. There are many problems that our societies face to which space could contribute an important solution.

We are suffering global climate change, driven by fossil fuel consumption required by the industrial age. Policy changes are needed, and they need to be based on facts, which can only be provided through space observations.

We need to increase the economic opportunities that are available to our societies. Perhaps by expanding our economic sphere to include the near space environment, the Moon, and asteroids. And why stop there?

Perhaps we will decide that the future of fundamental physics is in understanding dark energy, which appears to be powering the expansion of the universe. The expectation is that future societies will depend on and profit from the discoveries we make, as has always occurred in fundamental physics. If we decide to extend human presence into space, we no longer have the luxury of treating the conditions and the hazards of space as an interesting scientific problem to be solved at our leisure. Rather, there is a compelling scientific need to develop a true predictive capability of the space environment through which humans will travel.

It cannot be that we occupy this vast universe alone. Where are the other life forms? Finding someone else out there will profoundly alter the course of human history.

There is a worldwide need for technically competent workforces to solve the many problems facing our societies and to ensure our economic futures. Space has a proven record of creating technically competent workforces.

Above all, there is a worldwide need to believe that the future can be better than the present and to collectively work to secure that brighter future. Space is all about the future. We envision a time when our planet is safe from ourselves. When our economics grow without bound. When our knowledge of the wonders of the universe becomes true understanding. When we are a true space-faring civilization.

During the past 50 years, space has had a profound impact on our societies. It has facilitated the globally interdependent world in which we live. It has forever altered our sense of our place in the universe. It is my fervent hope that in the years ahead we will be called upon to do so much more. We can make it a much better world, if we are set loose and supported to do so.

Lennard A. Fisk
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This quarter’s column was written by Space Studies Board Associate Director Brant Sponberg. Brant has prior experience working on the NASA budget at the White House Office of Management and Budget and at NASA Headquarters. He offers the following guide to federal budget decision-making and its impact on NASA’s science budget.

The Presidential Transition and the NASA Science Budget

Presidential transitions create a time of change and uncertainty in the federal budget, not only in terms of altered budget priorities as the new administration comes into power, but also in the very timing of the annual budget cycle. As in many sports, when watching the federal budget process play out, one must pay attention to both the players and the clock.

Conceptually, all appropriations bills are passed and signed into law before the start of a new fiscal year (FY) on October 1. This process starts when the White House submits its budget request to Congress in February. Congress deliberates on the President’s budget request with a goal of passing the 12 appropriations bills that fund federal agencies by the October 1 deadline. Usually, that deadline is not met, but the bills are passed before the end of the calendar year with short-term “continuing resolutions” (CRs) funding the agencies in the interim at their prior-year levels. In one case (FY 2003), passage of the bills covering most of the federal agencies (including NASA) was delayed until February of the following year, and in another instance (FY 2007), the bills for most federal agencies (including NASA) never passed. Those agencies had to operate under a CR that funded them at the prior year’s level for the entire year.

For the current fiscal year under consideration by Congress, FY 2009, it appears that most appropriations bills will not be passed until after the Presidential inauguration. Instead, Congress will pass one or more CRs to keep NASA’s programs and other federal programs funded at their current levels for some number of months. This strategy appears to be based on the hope that Democrats will retain control of Congress and a Democratic President will be elected to the White House in November, making budget negotiations easier than they have been with the current administration.

What will happen to NASA while Congress waits for the results of the election and for the new President to take office? Under a CR, NASA’s budget levels will be held at the amounts the agency received for FY 2008. Although the specifics depend heavily on the accounting details, the resulting months of flat funding can present a problem for some large capital projects, such as spacecraft and launch vehicles in mid-development, which may be forced to defer their peak funding and stretch out their schedules. But as Congressman Alan B. Mollohan, Chairman of the House Appropriations Subcommittee on Commerce, Justice, and Science (which funds NASA) told attendees at the Space Studies Board’s 50-year Anniversary Colloquium on June 26, programs could actually benefit from this waiting game if the new President offers a better budget deal for NASA and other federal agencies than the current President. (A webcast and presentations from the colloquium, Space and Earth Science: 50 Years and Counting, will soon be available at <http://www.nationalacademies.org/ssb>.)

The White House’s budget process is also affected during a presidential transition. The White House Office of Management and Budget (OMB) usually submits the President’s budget request for the upcoming fiscal year to Congress during the first week in February. But knowing that the new President will alter and amend that budget request to suit their priorities, the sitting President may decide to submit a “current services” budget, which does not represent any policy decisions on the part of the White House and essentially maintains the status quo from the prior fiscal year. For the FY 2010 budget, OMB does plan to submit a current services budget as the last budget for President Bush. Thus, all White House policy decisions on the FY 2010 budget
Within NASA itself, the most significant budget driver over the next few years will be the timing of the space shuttle’s retirement and how the resulting savings, approximately $3 billion per year, are spent. There are currently bills before Congress that would add flights to the remaining space shuttle manifest, that could delay retirement and add internal pressure to the NASA budget. Shuttle retirement savings are also slated to be spent on the development of new human space transport systems under the Constellation Program to support the International Space Station and lunar expeditions. The extent to which the new administration defers or accelerates the development of these new human space transport systems will provide or limit opportunities for the NASA science budget to grow. For example, if elected President, Senator McCain has stated that he plans to freeze the discretionary budget in FY 2010 and undertake a review of all discretionary programs. Senator Obama has similarly promised to cut wasteful government spending. Although it is impossible to predict the outcome of such reviews, if NASA was not exempt from such a discretionary budget freeze, NASA’s budget would be held to zero growth for that year.

Within the non-defense discretionary budget, NASA’s science programs compete most keenly for a share of the Federal Science and Technology Budget, which totals $61.7 billion, or 13 percent, of the total non-defense discretionary budget in the FY 2009 budget request. Not all of NASA’s activities are counted in the Federal S&T Budget, but the portions that are, including NASA’s science programs, total $5.5 billion, or nine percent of the Federal S&T Budget. OMB, working with the White House Office of Science and Technology Policy (OSTP) and other White House offices, usually provides guidance to departments and agencies regarding S&T priorities, which often results in budget initiatives, such as the Bush administration’s American Competitiveness Initiative. The S&T priorities of the new administration, and the extent to which NASA programs can address those priorities, can provide or limit opportunities for growth in the NASA science budget. For example, if elected President, Senator Obama has promised to double federal spending on basic research, which could benefit NASA’s science programs. But Senator Obama has also promised to spend $150 billion on energy technology development and deployment, which could compete with NASA’s science programs for S&T spending. Senator McCain has similarly promised new spending initiatives in energy technologies. It is impossible to know if such campaign promises will translate into budget decisions, and although the need for federal S&T investment is generally recognized, the new administration will have multiple S&T investment options available to it.

Within NASA itself, the most significant budget driver over the next few years will be the timing of the space shuttle’s retirement and how the resulting savings, approximately $3 billion per year, are spent. There are currently bills before Congress that would add flights to the remaining space shuttle manifest, that could delay retirement and add internal pressure to the NASA budget. Shuttle retirement savings are also slated to be spent on the development of new human space transport systems under the Constellation Program to support the International Space Station and lunar expeditions. The extent to which the new administration defers or accelerates the development of these new human space transport systems will provide or limit opportunities for the NASA science budget to grow. Of course, the performance of NASA’s science programs themselves is an important factor in the budget outcome. Programs that experience cost growth may become targets for budget cuts or, as often happens, siphon funds from other programs to pay the difference.

Even in a normal year, the federal budget cycle is a complex process with multiple players competing in a multi-phase dance. It becomes even more so during a Presidential transition, when the new administration’s budget decision-making schedule for up to three fiscal years is compressed into a single year. We on the Space Studies Board staff will do our best to keep track of these decisions and report on them in this newsletter. On page 9 of this issue, you can find summaries of the current FY 2009 authorization and appropriations bills currently working their way through Congress. There will be much more budget activity in the next year-and-a-half, and we look forward to watching and reporting on the action!
The Space Studies Board welcomes six new members, including our new chair, whose terms will cover the period 2008-2010. They are Charles F. Kennel (NAS), Scripps Institution of Oceanography (SIO) and the University of California, San Diego (UCSD), who will serve as chair; Yvonne Brill (NAE), Consultant; Andrew Christensen, Dixie State College and The Aerospace Corporation; Joan Johnson-Freese, Naval War College; Robert Pappalardo, Jet Propulsion Laboratory; and Ellen Zweibel, University of Wisconsin, Madison.

Charles (Charlie) Kennel is no stranger to the Board, having most recently served as co-chair of the NRC Committee on NASA’s Beyond Einstein Program: An Architecture for Implementation. He is a professor and director emeritus at the Scripps Institute of Oceanography and was the founding director of the UCSD Environment and Sustainability Initiative, an all-campus effort embracing teaching, research, campus operations, and public outreach; he is now chair of its international advisory board. Dr. Kennel is also chair of the California Council on Science and Technology. His research covers plasma physics, space plasma physics, solar-terrestrial physics, plasma astrophysics, and environmental science and policy.

Yvonne Brill (NAE) is an independent consultant whose primary focus is aerospace technology and policy issues. Her specific research interests include rocket motors (both liquid and solid propellant) for launch vehicles and spacecraft (on-board) propulsion systems. She began her career with Douglas Aircraft as a rocket-propellant chemist on a project to design and launch an uncrewed, Earth-orbiting satellite. Ms. Brill is currently one of only two women who have the distinction of being Honorary Fellows of the American Institute of Aeronautics and Astronautics.

Andrew Christensen is on the staff of Dixie State College and he is a part-time employee of The Aerospace Corporation. He previously held the position of chief scientist in the Civil Space Division at Northrop-Grumman Space Technology. He retired from Aerospace in 2003 and completed a two-year assignment with NOAA/NESDIS as their representative to the European Meteorological Satellite Organization in Darmstadt, Germany. Dr. Christensen’s research interests include the physics of the upper atmosphere and ionosphere.

Joan Johnson-Freese is chair of the Department of National Security Decision Making at the Naval War College (NWC). Prior to that, she held positions as chair of the Transnational Studies Department at the Asia Pacific Center for Security Studies in Honolulu, Hawaii, as a faculty member at the Air War College in Montgomery, Alabama, and as director of the Center for Space Policy and Law at the University of Central Florida. Dr. Johnson-Freese has focused her research and writing on security studies generally, and space programs and policies specifically. Dr. Johnson-Freese’s most recent book is Space as a Strategic Asset (2007). Her next book, Heavenly Ambition: Will America Dominate Space?, is scheduled for release in 2009.

Robert Pappalardo is a senior research scientist in the Planetary Science Division of the Jet Propulsion Laboratory. He also holds a visiting faculty position in the Division of Geological and Planetary Sciences at the California Institute of Technology and in the Department of Geological Sciences and Laboratory for Atmospheric and Planetary Sciences at the University of Colorado, Boulder. His research interests focus on the study of processes that have shaped the icy satellites of the outer solar system, particularly Jupiter’s moon Europa. He is also involved in the study of the nature, origin, and evolution of bright grooved terrain on Jupiter’s moon Ganymede—specifically the style of tectonism. Dr. Pappalardo is the new co-chair of the SSB’s Committee on the Origins and Evolution of Life.

Ellen Zweibel is a professor of astronomy and physics at the University of Wisconsin, Madison (UW). Prior to joining UW, Dr. Zweibel was a faculty member at the University of Colorado. Her research area is theoretical astrophysics, with emphasis on plasma astrophysics. She is affiliated with the Plasma Physics Program at UW, and is a member of the Center for Magnetic Self Organization. Dr. Zweibel’s work covers the origin and evolution of astrophysical magnetic fields—in stars, galaxies, and the intergalactic medium—and the ways in which magnetic fields affect their environments.

For more information on the membership of the SSB please visit our website at <www.nationalacademies.org/ssb>.
Forging the Future of Space Science—The Next 50 Years

The Space Studies Board completed its series of events commemorating the 50th anniversary of the International Geophysical Year and looking towards the next 50 years of discoveries that await us.

The final two regional events were held in Boulder, Colorado, and Fairmont, West Virginia. Each involved an afternoon panel session of local scientists who addressed the future of space science in various disciplines, followed by an evening lecture. The featured lectures were delivered in Boulder by Edward C. Stone, Professor of Physics, Caltech, and Voyager Project Scientist, JPL (Voyager’s Journey to the Edge of Interstellar Space), and in Fairmont by Charles Elachi, Director, JPL (Future of space and Earth Robotic Exploration: Scientific and Technological Challenges).

The final event of the series, a day-long colloquium entitled Space and Earth Science—50 Years and Counting, was held on July 26, which is the actual 50th birthday of the Space Studies Board. The colloquium opened with a welcome from Ralph Cicerone, president of the National Academy of Sciences, who also introduced Congressman Alan B. Mollohan. Mr. Mollohan chairs the House appropriations subcommittee that funds NASA, and spoke on the topic of Space and Earth Science—A View from Capitol Hill. Other events during the day included a panel session entitled The First 50 Years of Space and Earth Science: The Role of the SSB, featuring the current and past Board chairs; an on-stage interview of incoming SSB chair Charles Kennel by Washington Post space reporter Marc Kaufman; and four town hall sessions on astrophysics and space physics, microgravity life and physical sciences, planetary exploration and astrobiology, and Earth science and applications from space. The colloquium ended with a presentation from Laurie Leshin, NASA Goddard Space Flight Center, entitled Humans and Robots: Exploring Space Together.

The colloquium was followed by a reception and lecture at the Smithsonian Institution’s National Air and Space Museum where the SSB awarded its first James A. Van Allen Lectureship for Career Achievement in Space and Earth Science Research to Dr. Frank B. McDonald (NAS). Dr. McDonald then presented a lecture on Explorer 1: Gateway to the Never Ending Wonders of Space Science. Webcasts, podcasts, and presentation files from the Forging the Future of Space Science events can be found at <http://www7.nationalacademies.org/ssb/International_Public_Seminar_Series.html>.
SSB ACTIVITIES

THE BOARD AND ITS STANDING COMMITTEES

The Space Studies Board (SSB) held its 156th meeting at the National Academies’ Keck Center in Washington, D.C., on June 25, 2008. This one-day meeting included an update on NASA’s Science Mission Directorate from Ed Weiler, the new Associate Administrator for Science and Paul Hertz, SMD Chief Scientist; an update on NASA’s Constellation Program from Jim Norman (NASA/ESMD); an industry panel on Launch Vehicle Options for Delta 2-class space science missions with Dan Collins (United Launch Alliance), Bob Richards (Orbital Sciences Corporation), and Larry Williams (Space Exploration Technologies Corporation); and an update on the National Academies’ study on Climate Change Adaptation and Mitigation from Chris Elfring, director of the NRC Board on Atmospheric Sciences and Climate. The next full board meeting will be at the Beckman Center in Irvine, CA, on November 18. The SSB’s Executive Committee will meet August 18-20 in Woods Hole, MA.

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

The Committee on Earth Studies (CES) met April 7-8 in Washington, D.C. Guests at the meeting included the director of NASA’s Earth Science Program, Michael Freilich, and the head of NOAA/NESDIS, Mary Kicza. In addition to receiving updates on the status of NASA and NOAA Earth observation programs, Dr. Freilich and Ms. Kicza led discussions of potential new studies for ad hoc committees of the SSB. The next meeting of CES will be hosted by UCAR and will occur on September 22-23, 2008 in Boulder, Colorado.

The committee is also collaborating with other units in the NRC to organize a workshop which will explore uncertainty management in remote sensing, with an emphasis on remotely-sensed climate information. Through invited presentations and discussion, the participants will (1) examine sources of uncertainty throughout satellite and other remote data collection systems, including issues of sampling, scale, processing, and validation; (2) describe the statistical methods currently used to quantify these sources of uncertainty for climate-relevant data; and (3) explore how modern statistical methods might be used to provide a more powerful framework for characterizing and propagating these uncertainties. An ad hoc committee will plan and conduct the workshop, and a designated rapporteur will prepare an individually-authored summary of the proceedings. The workshop is tentatively planned for early December 2008.

Finally, several members of the committee are participating in the planning of the National Academies’ study on Climate Change Adaptation and Mitigation, a major initiative that will focus on providing decision-makers with near-term options related to mitigation and adaptation to anticipated climate change.

The Committee on the Origins and Evolution of Life (COEL) held its second meeting of 2008 at the National Academy of Sciences in Washington, D.C., on May 13-15. In addition to briefings on the current status of NASA’s Astrobiology and related programs, the committee devoted a significant amount of time to presentations, discussions, and deliberations concerning the origins and early evolution of life.

The membership terms of COEL’s co-chair, Bruce M. Jakosky, and committee members, Jan P. Amend, Michael H. Carr, Harry Y. McSween, Andrew Steele and Meenakshi Wadhwa ended on June 30. Robert T. Pappalardo of the Jet Propulsion Laboratory assumed the role of COEL co-chair on July 1. Appointments of new committee members will take place in the near future.

Future meetings of COEL will take place on the following dates: October 22-24, in Irvine, CA, and February 18-20, 2009, in Washington, D.C.

The Committee on Planetary and Lunar Exploration (COMPLEX) did not meet during this period. The committee is currently organizing a meeting for Aug. 20-22, 2008, in Woods Hole, MA, that will focus on the planning for the solar system exploration decadal survey.

The Committee on Solar and Space Physics (CSSP) will hold its second meeting of 2008 in September at the University of Colorado’s Laboratory for Atmospheric and Space Physics in Boulder, CO. The committee will discuss topics for potential future workshops and studies. On April 1-2, the committee held its first meeting of 2008 at the National Academies’ Keck Center in Washington, D.C., where it received presentations on the current state of NASA and NSF’s solar and space physics programs, NASA’s research and analysis grant program, ground-based neutron monitors, and an economic analysis of the impacts of space weather.
STUDY COMMITTEES

An ad hoc **Committee on the Assessment of NASA’s Research and Analysis Program** is being formed to conduct a study of mission-enabling activities in NASA’s space and Earth sciences program. The study will identify the appropriate roles for mission-enabling activities and metrics for assessing their effectiveness. It will also evaluate how, from a strategic perspective, decisions should be made about balance between mission-related and mission-enabling elements of the overall program as well as balance between various elements within the mission-enabling component. A proposal was sent to NASA in May and funding was committed in early July.

An ad hoc **Committee on Rationale and Goals for the U.S. Civil Space Program** is being organized under the auspices of the SSB and the Aeronautics and Space Engineering Board (ASEB) to prepare a report to advise the government on critical issues in U.S. space policy. The committee will, inter alia, analyze the rationale for U.S. efforts in space and the elements comprising leadership in this area; examine the balance and interfaces between fundamental scientific research in space, human space exploration, and applications of space technology and civil space systems for societal benefits; assess the role that commercial space companies can play in fulfilling national space goals and the proper role of the government in facilitating the emergence and success of commercial space companies; and recommend options for government attention to address and potentially resolve problems that the committee might identify.

The committee will identify issues that are critically important to the future vitality and progress of the U.S. civil space program and recommend options to address and resolve critical issues. Committee chair Gen. Lester Lyles (USAF retired) and two vice chairs, ASEB chair Raymond Colladay and retiring SSB chair Lennard Fisk, have been appointed, and the remaining committee roster is being completed. The committee should complete its work in the first half of 2009.

The third meeting of the ad hoc **Heliophysics Performance Assessment Committee** is scheduled for August 25-27 at the National Academies’ Beckman Center in Irvine, CA. The committee is tasked with studying the alignment of NASA’s Heliophysics Science Division with previous NRC advice, primarily the NRC solar and space physics decadal survey, *The Sun to the Earth and Beyond*. This is the SSB’s third mid-decade assessment of the activities of a NASA science division and is preceded by two NRC reports: *A Performance Assessment of NASA’s Astrophysics Program* and *Grading NASA’s Solar System Exploration Program: A Midterm Report*. The committee held its second meeting June 9-11 at the High Altitude Observatory in Boulder, Colorado, where it received presentations from NASA’s Mission Operating Working Groups, NOAA’s Space Environment Center, and the NRC’s Committee on Solar and Space Physics. The committee also conducted site visits to NASA’s Goddard Space Flight Center and the Johns Hopkins University Applied Physics Laboratory on May 13, where it received briefings on relevant programs and missions.

An ad hoc **Committee on Near-Earth Object Surveys and Hazard Mitigation Strategies** is being formed. The committee will undertake a two-phase study which will review the two NASA reports, *2006 Near-Earth Object Survey and Detection Study* and *Near-Earth Object Survey and Deflection Analysis of Alternatives: Report to Congress*, and other relevant literature and provide recommendations that will address two major issues: the best approach to completing the NEO census required by Congress to identify potentially hazardous NEO’s larger than 140 meters in diameter by the year 2020; and the optimal approach to developing a deflection strategy and ensuring that it includes a significant international effort. The study will include an assessment of the costs of various alternatives, using independent cost estimating. A proposal was sent to NASA in June and funding was committed in early July.

An ad hoc **Committee on Planetary Protection Requirements for Mars Sample-Return Missions** is in the process of being appointed. A slate of candidates was prepared and submitted to the NRC’s Executive Office for approval in early July. The committee plans to meet twice—at Arizona State University in Tempe, Arizona, on August 12-14 and at the National Academy of Sciences in Washington, D.C., on September 8-10—and issue a short report in late-October/early-November.

An ad hoc **Committee on Radioisotope Power Systems** is being formed. The committee will address the following issues: (1) the technical readiness and programmatic balance of NASA’s RPS technology portfolio to support NASA near- and long-term mission plans; (2) the effectiveness and ability of U.S. government agency management structures, including participating organizations, roles, and responsibilities, to meet stated goals and objectives of U.S. programs for RPS capabilities within the current statutory and policy framework; (3) the importance to the national interest of maintaining and/or re-establishing needed infrastructure at field centers, laboratories, and the private sector R&D base, given the recent curtailment of RPS program content and ambitious national goals in space exploration; (4) the strategies for re-establishment of 238Pu domestic production versus the likelihood of continued procurement of Russian-produced material in view of potential competition for 238Pu fuel from other space-faring nations and the critical shortage of U.S.-owned inventory; and (5) the identification of any actions that could be taken in the context of the overall RPS program to meet stated science and exploration goals. A proposal was sent to NASA...
in May and funding was received in early July.

The ad hoc Committee to Review the NASA Astrobiology Institute has completed all of its planned activities. Its report, Assessment of the NASA Astrobiology Institute, was delivered to NASA on March 21. The chair and members of the committee briefed the associate administrator from the Science Mission Directorate and other officials on the results of the study at NASA headquarters on May 13.

The ad hoc Committee on Science Opportunities Enabled by NASA’s Constellation System released its interim report to NASA in late April and publicly in early May. The committee is charged with evaluating what opportunities the Constellation program hardware might enable new science missions. The committee also issued a request for information to the scientific community. It received six responses which were evaluated during the committee’s third meeting in Boulder, CO, on June 9-11. The committee’s final meeting, primarily devoted to writing the final report, is being held August 4-6 in Woods Hole, MA. The committee’s final report is due in November.

The ad hoc Committee on the Societal and Economic Impacts of Severe Space Weather Events Workshop held a workshop on May 22-23, 2008, at the Washington Plaza Hotel in Washington, D.C. Approximately 80 representatives from industry, government agencies, and academia were in attendance. The workshop was divided into topic panels that focused on the nation’s current and future ability to manage the effects of space weather events and their societal and economic impacts. About 25 invited speakers discussed issues for specific systems such as satellites, communications, the power industry, and airlines. The workshop was successful in generating a vigorous information exchange and discussion among its diverse participants. The planning committee met in closed session immediately following the workshop and adjourned on May 25. Presentations from the workshop were subsequently posted online and the committee is currently drafting a summary report of the workshop.

The ad hoc Committee on a Strategy to Mitigate the Impact of Sensor Descopes and De-manifests on the NPOESS and GOES-R Spacecraft was formed shortly before the SSB workshop in June 2007 on Options to Ensure the Climate Record from the NPOESS and GOES-R Spacecraft. NASA and NOAA requested that the NRC form this ad hoc committee to carry out a fast turn-around follow-on study that would: (1) prioritize capabilities, especially those related to climate research that were lost or placed at risk following recent changes to NPOESS and the GOES-R series of polar and geostationary environmental monitoring satellites; and (2) present strategies to recover these capabilities.

This study was completed at the end of the quarter with the release of a pre-publication version of the report, Ensuring the Climate Record from the NPOESS and GOES-R Spacecraft: Elements of a Strategy to Recover Measurement Capabilities Lost in Program Restructuring (available online with a link for free PDF download at <http://www.nap.edu/catalog.php?record_id=12254>). For convenience, this report also has an appendix that reproduces the final, edited version of the report from the June 2007 workshop. Publication of the final, edited version of Ensuring the Climate Record from the NPOESS and GOES-R Spacecraft is anticipated in late September.

The final version of the report from the November 2007 SSB-ASEB Workshop on U.S. Civil Space Policy, United States Civil Space Policy: Summary of a Workshop, was released on May 2. The report presents highlights of the November 2007 workshop that was organized to encourage national discussion about future directions of the U.S. civil space program. Approximately 60 participants from government, industry, and academia contributed expertise that spanned the fields of human spaceflight, space science, commercial space, science and technology policy, economics, international relations, and the media. They debated questions regarding the status, content, roles, national and international context, and sustainability of the civil space program. The report summarizes the workshop discussions, particularly with respect to participants’ views on program robustness, international context, and public interest and support. It describes participants’ perspectives about how factors such as program resources, leadership, relevance and value, and balance impact the sustainability of the civil space program. It also devotes specific attention to issues regarding Earth observations from space and to capabilities and infrastructure that will be needed for future space exploration endeavors. The goal of the workshop was not to develop definitive answers to any of these questions but to air a range of views and perspectives that would serve to inform subsequent broader discussion of such questions by policymakers and the public.

Other Activities

The Committee on Space Research (COSPAR) of the International Council of Science is preparing for the its biennial Scientific Assembly, to be held in Montreal, Canada, on July 13-19.

A Meeting of Experts on the Organization of a Decadal Survey in Microgravity Research was held on May 15-16, at the National Academy of Sciences in Washington, D.C. Invited experts in physical and life sciences research heard presentations from NASA’s Exploration Systems Mission Directorate program on the agency’s strategy for implementing its exploration
program and on the history of NASA’s space life and physical sciences research over the last five years. Subsequent discussion between the invited experts and NASA representatives focused on the potential scope of a congressionally-requested study in microgravity research, the opportunities and barriers to science community input and participation in the study, the organization of the study’s steering committee and panels, and the likely utilization of the report. The comments of the invited experts at the meeting are being considered by NASA and the NRC in the development of a task statement for the decadal survey.

**NEW RELEASES FROM THE SSB**

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**Ensuring the Climate Record from the NPOESS and GOES-R Spacecraft: Elements of a Strategy to Recover Measurement Capabilities Lost in Program Restructuring**

This report by the Committee on a Strategy to Mitigate the Impact of Sensor Descopes and Demanifests on the NPOESS and GOES-R Spacecraft is available at <http://books.nap.edu/catalog.php?record_id=12254>. The study was chaired by Antonio Busalacchi, Jr. and staffed by Arthur Charo, Study Director, Theresa M. Fisher, Program Associate, and Catherine A. Gruber, Assistant Editor.

The nation’s next-generation National Polar-orbiting Operational Environmental Satellite System (NPOESS) was created by the Presidential Decision Directive/National Science and Technology Council (NSTC)-2 of May 5, 1994, that merged the military and civil meteorological programs into a single program. Within NPOESS, the National Oceanic and Atmospheric Administration (NOAA) is responsible for satellite operations, the Department of Defense (DOD) is responsible for major acquisitions, and the National Aeronautics and Space Administration (NASA) is responsible for the development and infusion of new technologies.

In 2000, the NPOESS program anticipated purchasing six satellites for $6.5 billion, with a first launch in 2008. By November 2005, however, it had become apparent that NPOESS would overrun its cost estimates by at least 25 percent, triggering a Nunn-McCurdy review by the DOD. The results of that review were announced in June 2006; among the notable changes in the “certified” NPOESS program were the following:

- The planned acquisition of six spacecraft was reduced to four.
- The planned use of three Sun-synchronous orbits was reduced to two, with data from the European Meteorological Operational (MetOp) satellites provided by the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) providing data for the canceled mid-morning orbit.
- The launch of the first spacecraft, NPOESS C1, was delayed until 2013.
- Several sensors were canceled (in common parlance, “demanifested”) or degraded (“descoped”) in capability as the program was refocused on “core” requirements related to the acquisition of data to support numerical weather prediction. “Secondary” (non-core) sensors that would provide crucial continuity to certain long-term climate records, as well as other sensors that would have provided new measurement capabilities, were not funded in the certified NPOESS program.

Since the 1970s, NOAA has operated geostationary satellites that provide images and data on atmospheric, oceanic, and climatic conditions over the continental United States and Hawaii from ~22,000 miles above the equator. NOAA’s next generation of geostationary weather satellites will commence with the launch of GOES-R in 2015. Originally, plans for this series included four satellites—GOES-R through GOES-U. However, in September 2006, following significant cost growth and estimates that the total program cost would nearly double, NOAA reduced the scope of the program, removed a key instrument on the spacecraft, the Hyperspectral Environmental Suite (HES), and revised the procurement process so that only two satellites are guaranteed.

These events prompted a request from NASA and NOAA for two National Research Council (NRC) efforts. The first, a workshop titled “Options to Ensure the Climate Record from the NPOESS and GOES-R Spacecraft” and held in Washington, D.C., on June 19-21, 2007, gave participants an opportunity to discuss options to recover measurement capabilities, especially those related to climate research, that were lost as a result of the Nunn-McCurdy actions and the cancellation of the HES on GOES-R. Some 100 scientists and engineers from academia, government, and industry attended the workshop, commenting on a draft mitigation plan developed by NASA and NOAA as well as exploring options not included in the NASA-NOAA report. A prepublication version of the workshop report (NRC, 2007a) was released in October 2007.

The second NRC effort, a study documented in the present report, builds on the information gathered at the June 2007 workshop. In their request for this study (Appendix A), NASA and NOAA asked that a committee of the NRC “prioritize capabilities, especially those related to climate research, that were lost or placed at risk following recent changes to NPOESS and the GOES-R series of polar and geostationary environmental monitoring satellites” [emphasis added].

The Committee on a Strategy to Mitigate the Impact of Sensor Descopes and Demanifests on the NPOESS and GOES-R Spacecraft understands...
“climate” to be, “the statistical description in terms of the mean and variability of relevant measures of the atmosphere-ocean system over periods of time ranging from weeks to thousands or millions of years.” (Climate Change Science Program and the Subcommittee on Global Change Research, 2003, p. 12). In the present study, the committee primarily considered climate related physical, chemical, and biological processes that vary on interannual to centennial timescales. It is also important to note that the committee did not a priori assume a longer-duration measurement record would be assigned a higher priority than a shorter-duration measurement record. Instead, the committee considered each measurement’s value to climate science in a more comprehensive sense as described in the Prioritization Process section below. The committee interprets the information needed for climate research broadly to be that which enables:

- Detection of variations in climate (through long-term records),
- Climate predictions and projections, and
- Improved understanding of the physical, chemical, and biological processes involved in climate variability and change.

In performing its prioritization, the committee was cognizant of the scientific importance of maintaining long-term records of climate forcing and improving understanding of the climate system through starting or continuing records of climate responses. It also recognized the challenges of finding an appropriate balance between observations of climate forcing and response on the one hand, and sustained observations/“monitoring” and improved “process” understanding on the other. The committee notes that its interpretation of the research agenda for climate-related issues is consistent with the five goals of the U.S. Climate Change Science Program (Box S.1).

**APPRAOCH TO AND SCOPE OF PRIORITIZATION**

Conducted during its December 17-19, 2007, meeting, the committee’s prioritization of capabilities lost in program restructuring was guided by the following overarching principles:

- The objective of the committee’s deliberations would be to prioritize for the restoration of climate capabilities. For example, although a sensor with the capability to improve resolution of fast climate processes is of interest to both the weather forecasting and the climate research communities, it is the value to the latter that would inform the committee’s ranking.
- The particular strategy for recovery and the cost of recovery of a measurement/sensor would not be a factor in the ranking.
- Measurements/sensors on NPOESS would not be ranked against measurements/sensors on GOES-R; however, the criteria used in ranking measurements/sensors for either program would be identical.
- When it was relevant, the measurement objectives of a particular sensor, and not the sensor itself, would be the basis for consideration. Thus, for example, members of the committee considered the importance of radar altimetry to climate science, rather than the importance of the particular implementation of this capability on NPOESS, that is, the ALT instrument.

Prior to the meeting, one or more committee members with the requisite expertise was assigned the task of preparing a detailed review of the issues associated with the descoping or demanifesting of a particular NPOESS or GOES-R measurement capability, guided by questions 1 through 9, below. These questions, which were developed at the committee’s first meeting, follow from the committee’s interpretation of what constitutes climate science and the associated requirements for climate observations (see above); they allow a prioritization across the diverse information requirements for climate science, for example, long-term measurements, new measurements, measurements of climate forccings and responses, measurements to improve scientific understanding and reduce key uncertainties, and measurements to improve climate predictions. The questions are also consistent with the ranking criteria employed by the panels of the NRC Earth science and applications from space decadal survey (NRC, 2007), although in that study societal benefits and cost considerations were included as ranking factors.

By design, the questions were open-ended in order to provoke a more nuanced discussion of the value of the measurements. For example, rather than merely listing the duration of the measurement records at risk as a proxy for value, the committee considered the value of a long-term record in a more holistic manner via questions 1 and 5, which in turn prompted an in-depth exploration of the value of the long-term record, the impact of the record on global climate studies, the relative impact/consequences of a gap in the record, the maturity of related data assimilation, and sensor heritage. Such an analysis was considered important in the prioritization process in order to appropriately balance the need to continue very-long-duration measurements with shorter-duration measurements. The former would benefit with better scores for measurement/sensor maturity and the value of maintaining the long-term record. The latter measurements, although perhaps less mature, might result in greater consequences associated with a prospective measurement gap (for example, those related to climate forcing/response parameters with larger uncertainties for which longer trend data can greatly constrain future climate predictions).

1. To what extent are the data used both to monitor and to provide a historical record of the global climate? Is there a requirement for data continuity? If so, discuss the consequences of a measurement gap.
2. To what extent is this measurement important in reducing “uncertainty”—for example, in reducing error bars in climate sensitivity forcing and monitoring? In making these judgments, refer also to the priorities of the Climate Change Research Program.
3. Consider the importance of the measurement’s role in climate prediction and projections (forcing/response/sensitivity).
4. To what extent is the measurement needed for reanalysis?
5. Describe the measurement’s maturity—for example, its readiness to be assimilated into a particular model(s)—and its heritage. If discussing a sensor, discuss its technical maturity and heritage.
6. Are other sensors and ancillary data required to make the measurement useful? Is this measurement unique? Are there complementary international sensors? If so, please list them and assess their capabilities. Discuss any data issues you may be aware of.
7. To what extent are the data used by, for example, the Intergovernmental Panel on Climate Change and the Climate Change Science Program (in developing synthesis and assessment products)?
8. Provide a qualitative assessment of the measurement’s role in contributing to an overall improved understanding of the climate system and climate processes.
9. To what extent does the measurement contribute to improved understanding in related disciplines?
Following each reviewer presentation, committee members actively discussed the measurement objective under consideration in relation to each of the nine questions. The committee’s prioritization was developed on the basis of numerical scoring of the importance of each measurement capability to the needs of the climate research community (questions 1-8) and the importance of the measurement to related disciplines (question 9). Each of the responses to questions 1 through 9 was given equal weight in determining an overall ranking.

The committee had extensive discussions regarding whether a simple average of committee member rankings of the responses to questions 1 through 9 should be used for an overall ranking, or whether rankings with respect to particular questions should be given more weight. In part because there was no consensus among committee members on how a particular weighting scheme might improve what was already a subjective evaluation (in mapping the study statement of task to the questions, and in assigning individual numerical rankings for each question), the committee determined that the use of an unweighted average was advisable. Given that the committee was not provided any information concerning costs, relative or absolute, for any of the proposed mitigations, its prioritization of measurement capabilities was based entirely on climate science value as determined by consideration of the nine questions above. Lacking the information by which to determine the financial implications of its recommendations, the committee did not include implementation costs in its rankings.

The committee notes, however, that had costs been provided, a more far-reaching set of recommendations might have been developed in which cost/benefit was taken into consideration. It is also important to recognize that important nonscientific factors were not, by design, part of the committee’s analysis.

Before restructuring, each of the lost or degraded measurement capabilities had been considered both practicable and of high importance. In the case of NPOESS, a tri-agency under-secretary-level executive committee provides overall program direction and ensures that both civil and national security requirements are satisfied. GOES-R requirements had been established by NOAA following a formal process that determined and prioritized user requirements; various senior management committees oversaw this process. As is evident in the “Highlights of Analysis” sections in Chapter 3, the committee also found great merit in each of the climate-related measurement capabilities under consideration. However, given that a wholesale reversal of the program changes was not feasible, it became the committee’s difficult task to provide a prioritized set of recommendations for restoration of climate measurement capabilities.

**SUMMARY OF PRIORITIES AND MITIGATION OPTIONS**

The committee prioritized all of the climate-related measurement capabilities that were lost or diminished as a result of NPOESS and GOES-R program restructuring rather than limiting its recommendations to the demanifested sensors as was done in the NASA-NOAA draft report prepared for OSTP. The committee’s approach is consistent with input received from the community as part of the NRC’s June 2007 workshop. Specifically, with respect to changes in the NPOESS program, the committee considered:

- Aerosol properties and the Aerosol Polarimetry Sensor (APS),
- Earth radiation budget and the Clouds and Earth’s Radiant Energy System/Earth Radiation Budget Sensor (CERES/ERBS),
- Hyperspectral diurnal coverage and the Cross-track Infrared Sounder (CrIS),
- Microwave radiometry and the Conical Scanning Microwave Imager/Sounder (CMIS),
- Ocean color and the Visible/Infrared Imager/Radiometer Suite (VIIRS),
- Ozone profiles and the Ozone Mapping and Profiler Suite-Limb (OMPS-L) sensor,
- Radar altimetry and the ALT sensor, and
- Total solar irradiance and the Total Solar Irradiance Monitor (TIM)/spectrally resolved irradiance and the Solar Spectral Irradiance Monitor (SIM).

With respect to changes in the GOES-R program, the committee considered:

- Geostationary coastal waters imagery and the HES-CWI Sensor, and
- Geostationary hyperspectral sounding and the HES Sensor.

As a result of the prioritization process, the measurements and sensors listed above are divided approximately into four groups, which the committee designates, in descending order of priority, as Tier 1 through Tier 4. These are shown in priority order in Figure S.1. As noted above, sensors from the NPOESS and GOES-R programs were not prioritized head-to-head. However, it can be roughly stated that considering climate science contributions alone, geostationary hyperspectral sounding compares to the NPOESS capabilities prioritized as Tier 2, and coastal waters imagery falls into Tier 4.

After completing the relative prioritization, the committee considered a wide range of options for recovery of the lost capabilities, including the remanifesting of sensors onto NPOESS platforms, accommodation of sensors on free flyers or flights of opportunity, and the use of formation flight to combine multiple, synergistic, measurement types without incurring the cost, complexity, and risk of large facility-class observatories. The committee’s recommendations for mitigation recovery of the lost capabilities are detailed in the main text and are summarized in Table S.1.

The color coding used in Figure S.1 and Table S.1—green, yellow, blue, and pink shading to indicate Tier 1, Tier 2, Tier 3, and Tier 4 prioritization, respectively—is used as an interpretive aid in the main text.

**ELEMENTS OF A LONG-TERM CLIMATE STRATEGY: A WAY FORWARD**

The committee has developed and recommends a prioritized, short-term strategy for recovery of crucial climate capabilities lost in the NPOESS and GOES-R program descopes. However, mitigation of these recent losses is only the first step in establishing a viable long-term climate strategy—one that builds on the lessons learned from the well-intentioned but poorly executed merger of the nation’s weather and climate observation systems. The key elements of such a long-term strategy are discussed in Chapter 4 and are summarized here.

**Sustained Climate Observations**

In developing an effective long-term climate strategy, it is critical to consider the similarities in and differences between research, operational, and sustained measurements in order to take advantage of synergies when appropriate while avoiding incompatible observing system requirements. Sustained measurements needed to detect climate trends can, for example, impose tighter requirements for calibration, characterization, and stability, or impose orbit constraints different from what would otherwise be required for operational applications. A long-term climate strategy must provide for the essential characterization, calibration, stability, continuity, and data systems required to support climate applications.
National Policy for Provision of Long-term Climate Measurements

Much of climate science depends on long-term, sustained measurement records. Yet, as has been noted in many previous NRC and agency reports, the nation lacks a clear policy to address these known national and international needs. For example, an ad hoc NRC task group (NRC, 1999b, p. 4) stated as follows:

No federal entity is currently the “agent” for climate or longer-term observations and analyses, nor has the “virtual agency” envisioned in the [U.S. Global Change Research Program] succeeded in this function. The task group endorses NASA’s call for a high-level process to develop a national policy to ensure that the long-term continuity and quality of key data sets required for global change research are not compromised in the process of merging research and operational data sets.

A coherent, integrated, and viable long-term climate observation strategy should explicitly seek to balance the myriad science and applications objectives basic to serving the variety of climate data stakeholders. The program should, for example, consider the appropriate balance between (1) new sensors for technological innovation, (2) new observations for emerging science needs, (3) long-term sustainable science-grade environmental observations, and (4) measurements that improve support for decision makers to enable more effective climate mitigation and adaptation regulations (NRC, 2006). The various agencies have differing levels of expertise associated with each of these programmatic elements, and the long-term strategy should seek to capitalize on inherent organizational strengths where appropriate. Elements of this needed national policy include clear roles and responsibilities for agencies, international coordination, and community involvement in the development of climate data records.

Clear Agency Roles and Responsibilities

In the NRC decadal survey Earth Science and Applications from Space, the authors stated, “The committee is concerned that the nation’s civil space institutions (including NASA, NOAA, and USGS) are not adequately prepared to meet society’s rapidly evolving Earth information needs. These institutions have responsibilities that are in many cases mismatched with their authorities and resources: institutional mandates are inconsistent with agency charters, budgets are not well matched to emerging needs, and shared responsibilities are supported inconsistently by mechanisms for cooperation. These are issues whose solutions will require action at high levels of the federal government” (NRC, 2007b, p. 13). In turn, this prompted one of the report’s most important recommendations: “The Office of Science and Technology Policy, in collaboration with the relevant agencies and in consultation with the scientific community, should develop and implement a plan for achieving and sustaining global Earth observations. This plan should recognize the complexity of differing agency roles, responsibilities, and capabilities as well as the lessons from implementation of the Landsat, EOS, and NPOESS programs” (p. 14). The present committee fully endorses the need for clarified agency roles and responsibilities, consistent with inherent agency strengths, and reiterates this important recommendation of the decadal survey.

International Coordination

The committee recognizes the importance of international cooperation in obtaining climate-quality measurements from space; the absence of an internationally agreed upon and ratified strategy for climate observations from space remains an area of grave concern. The research and operational agencies should coordinate their development, operations, standards, and products with international partners.

Community Involvement in the Development of Climate Data Records

The NRC has produced a number of reports on the subject of climate data records (CDRs), many having been motivated by concerns over the future availability of satellite-based climate-quality data records. The implied demise of climate-focused satellite observations from NPOESS, a consequence of the Nunn-McCurdy certification, adds to the ongoing concern about the lack of organized commitment to CDR development. It has been stressed in many NRC and other reports that generation of CDRs requires considerable scientific insight, including the blending of multiple sources of data; error analysis; and access to raw data. On the basis of its review of previous NRC studies and its own experience, the committee identified a number of particularly important elements for a sustained long-term program dedicated to developing credible CDRs. These elements are discussed in Chapter 4.

Finally, it is important to note that community concerns about the adequacy of NPOESS for climate research existed even before the 2006 program restructing. For example, in the 2007 NRC decadal survey Earth Science and Applications from Space, the report from the Panel on Climate Variability and Change concluded that, “Regardless of the descoping, the NPOESS program lacks essential features of a well-designed climate-observing system.”

United States Civil Space Policy: Summary of a Workshop

This report by Molly K. Macauley, rapporteur is available at <http://books.nap.edu/catalog.php?record_id=12202>. The study was staffed by Joseph K. Alexander, Study Director, Kerrie Smith, Program Officer, Carmela J. Chamberlain, Program Associate, Sandra Wilson, Program Assistant, and Catherine A. Gruber, Assistant Editor.

What are the principal purposes, goals, and priorities of the U.S. civil space program? This question was the focus of the workshop on civil space policy held November 29-30, 2007, by the Space Studies Board (SSB) and the Aeronautics and Space Engineering Board (ASEB) of the National Research Council (NRC). In addressing this question, invited speakers and panelists and the general discussion from this public workshop explored a series of topics, including the following:

- Key changes and developments in the U.S. civil space program since the new national Vision for Space Exploration (the Vision) was articulated by the executive branch in 2004;
- The fit of space exploration within a broader national and international context;
- Affordability, public interest, and political will to sustain the civil space program;
- Definitions, metrics, and decision criteria for the mix and balance of activities within the program portfolio;
- Roles of government in Earth observations from space; and
• Gaps in capabilities and infrastructure to support the program.

The workshop organizers acknowledged the long-standing problem of reconciling expectations of civil space program accomplishments during the coming decades with the limited public resources available to support these activities. The goal of the workshop was neither to develop definitive solutions nor to reach consensus. Rather, the purpose was to air a range of views and perspectives that would serve to inform broader discussion of such questions by policy makers and the public. This document summarizes the opinions expressed by individual workshop participants and does not necessarily reflect the consensus views of these participants, the SSB, or the workshop planning committee.

By way of background, the SSB and the ASEB had convened a similar workshop in 2003 in the wake of the space shuttle Columbia tragedy and the findings of the Columbia Accident Investigation Board. Since the issuance of the report on the 2003 workshop, Issues and Opportunities Regarding the U.S. Space Program: A Summary Report of a Workshop on National Space Policy, additional developments have taken place to redirect many elements of the civil space program. The Vision for Space Exploration set forth by the executive branch in 2004, the National Aeronautics and Space Administration (NASA) Authorization Act of 2005, and the national space policy presidential directive issued in 2006 have all served to redirect the program. The Vision sets forth a long-term robotic and human exploration program; the NASA Authorization Act of 2005 endorses the Vision and directs the program in several areas with respect to policy, management, and accountability and oversight; and the 2006 presidential directive establishes goals related to U.S. space leadership and the governance of space operations in and through space.

ROBUSTNESS OF THE CIVIL SPACE PROGRAM

The workshop summarized here thus builds on discussion from the 2003 workshop in light of these developments. A natural starting point was an assessment of the new directions for the U.S. civil space program: How robust or resilient are these new directions to changes in resources available to support the program? How relevant is the program in what many workshop participants see as a rapidly changing international context? Is there public appeal in terms of willingness to embrace the program? Many participants expressed the view that the Vision had not progressed as originally outlined nor as many had expected, due in large part to the failure of the administration and the Congress to seek the required resources. A prominent concern among participants was that although the Vision was to be “pay as you go,” shortfalls in the NASA budget had led the agency to reallocate resources toward pursuit of the Vision and away from other activities such as space and Earth science. Speakers argued that continued operational costs of the International Space Station, delayed phasen- out of the space shuttle, costs of near-term development of the next-generation space transportation system, and unbudgeted operational costs will all make the Vision increasingly unaffordable. Other participants acknowledged that some of the problems with robustness and program balance are of the space community’s own making, in that in many activities, project cost estimates had been unrealistic and subject to significant cost growth. Participants from within and outside the scientific community voiced agreement that the community will need to demonstrate leadership and share responsibility with NASA in controlling science program costs. Speakers expressed concern that NASA’s program suffers from a lack of resources, budget realism, and budget stability, thereby making the Vision unaffordable and unsustainable.

The recent report that focused on the space and Earth science issues at this workshop summarized the mood at the workshop as follows:

Overall, as noted by the participants themselves, the tone of the workshop was surprisingly sober, with frequent expressions of discouragement, disappointment, and apprehension about the future of the U.S. civil space program. During the one and one-half days of discussion, an oft-repeated statement by workshop participants was that the goals of the U.S. civil space program are completely mismatched with the resources provided to accomplish them.

INTERNATIONAL CONTEXT

In contrast with the 2003 workshop at which international developments were mentioned but did not play a pivotal role in discussion, international collaboration and competition were prominent topics at the 2007 workshop. Speakers summarized their understanding of the capabilities and ambitions of new national space programs in China and India, cited the forming of multinational alliances that exclude the United States or Europe, and pointed out some consequences of the U.S. International Traffic in Arms Regulations (ITAR) as examples of new challenges in balancing cooperation and competition in the U.S. civil space program. For example, speakers questioned whether a goal of cooperation conflicts with the objective in the Vision to support international participation to “further U.S. scientific, security, and economic interests.” Some participants suggested that international cooperation could provide a means to share costs, thereby augmenting resources available for the space program, but others noted that collaboration does not always result in reduced costs, particularly if partner roles and responsibilities are unclear. Participants also discussed at length the emergence of China as a major player in space and whether China presents a threat, in which case cooperation may be difficult or even out of the question, or an opportunity for engagement and cooperation, in which case space could gain a new strategic purpose as a vehicle for such cooperation. In any case, discussion highlighted that a decision about how to engage China will not be based solely on space policy, but will depend on much larger geopolitical considerations.

PUBLIC INTEREST AND SUPPORT

In assessing contemporary public interest in and support for space activities, some participants commented that programs such as the Hubble Space Telescope and the Mars rovers are popular and have a “wow factor”; other speakers suggested that as long as the NASA budget is not too large, a “wow factor” in space accomplishments becomes less important. Others noted some survey-based evidence that the greatest degree of enthusiasm for human space exploration rests with the Apollo generation (the 45- to 64-year-old age group), with much less support from the generation of youngest voters/the 18- to 24-year-old age group.

SUSTAINABILITY, RESOURCES, LEADERSHIP, RELEVANCE, AND BALANCE

Subsequent discussion turned to identifying problems in more detail, specifically to addressing a lack of resources, leadership challenges, the relevance and value of the space program, and balance among activities within the program. Speakers cited both internal and external factors that can affect resource requirements. Internal factors include project delays, inadequate contingency funds, pressures for “full employment” at NASA centers, and defensive behavior by program managers and others when resources are scarce. External influences include competition from China and India, the emergence of climate and
energy as major global issues, and likely continued federal budget deficits. Another concern was potential congressional opposition to U.S. reliance on Russia during an extended launch hiatus after the retirement of the space shuttle.

The question of leadership figured prominently in workshop discussions. Some participants argued that strong leadership at senior levels of NASA and the government is essential for the success of the space program. In this context, some speakers viewed with considerable urgency the desirability of senior leaders facing up to what was repeatedly described as a program that cannot be executed within the allotted budget. Speakers also reiterated the responsibility of the space community to establish sound cost estimates and to execute programs within realistic budgets.

Why should I care? Suggested by a participant as an appropriate question to be posed by candidates for major national office served to focus in-depth discussion about a rationale for the civil space program. There were considerable differences in opinion, ranging from historically offered reasons (science, national security, commercial activities, a sense of human destiny and exploration, and national prestige and geopolities) to a focus on the geopolitical contributions of the space program as perhaps one of the most compelling current-day rationales. But there was less than full agreement as to whether geopolitics meant cooperation or competition as a motivation for space activities. Discussion also addressed but did not reach agreement on whether, and if so to what extent, the civil space program needs to demonstrate practical benefits and value, a “wow” factor, or some mix of both.

Balancing the pursuit of science, human space exploration, aeronautics, and other dimensions of space activities was also a concern among participants. Some speakers cautioned against characterizing the problem as “humans versus robots”; others urged that the focus should be on identifying and exploiting synergies among different parts of NASA, among NASA and other agencies and countries, and between NASA and the private sector. Participants also suggested that assessing balance requires recognition that different constituencies have different objectives; for example, the scientific community measures much of its success in terms of progress toward goals such as those articulated in decadal surveys, whereas the aeronautics community measures progress in terms of responding to commercial and military air transport requirements.

**EARTH OBSERVING PROGRAMS**

Workshop discussion also addressed the role of Earth observations. Speakers emphasized that Earth observations necessarily assume even greater importance given evidence of possibly significant changes in climate. But they remained troubled by problems stemming from reorganization of responsibility for and funding of the National Polar-Orbiting Operational Environmental Satellite System (NPOESS) and the reduced capability of NPOESS in facilitating necessary climate-related measurements. Discussion also addressed the persistent difficulty between NASA and the National Oceanic and Atmospheric Administration (NOAA) in the “handoff” from use for research purposes to operational use of Earth science infrastructure and information. Speakers argued that differences in these agencies—ranging from culture to objectives—become even sharper when their budgets are declining.

**CAPABILITIES AND INFRASTRUCTURE**

Additional workshop discussion included optimistic comments about future capabilities and infrastructure to support the civil space program if national priorities can be well articulated and sufficient resources made available. For example, both traditional and new companies in aerospace can bring creativity and talent to problem solving when requirements are made clear. Speakers described experiences with bright university students interested in aerospace careers provided students sense that they can have an impact. Speakers further urged that NASA and universities build more effective partnerships to encourage talent and that ITAR restrictions limiting access to good students be remedied. Some participants mentioned institutions where turnover rates among aerospace professionals are very low, even at the present time. Discussion also addressed the attraction of many young people to space activities using contemporary media that create a virtual presence.

**CONCLUDING THEMES**

The workshop concluded with the consolidation of discussion topics, which fell into three broad categories: communicating about space exploration; international competition, cooperation, and leadership; and ensuring robustness through new approaches and attitudes. One idea for avoiding the impending programmatic “train wreck” to which many participants referred during the workshop was to “slow down the train” by deferring the first human mission to the Moon; extending the use of the International Space Station in support of research and development for later human exploration; establishing a telepresence on the Moon; creating an environment of institutional stability in NASA’s program elements; building globally inclusive working groups on direct missions to Mars, global change, and space science; and defining real, meaningful jobs for humans in space.
This past June, Congress approved the FY 2009 budget resolution with a total of $1.013 trillion for regular appropriations; a $21 billion increase over the President’s budget request. All of this increase will be allocated to nondefense programs. To distribute the total, both bodies in Congress began the lengthy process of drafting the 12 individual appropriations bills and further dividing those into program-by-program funding.

The allocation for the House Commerce, Justice and Science appropriations bill is $56.9 billion, a $3.2 billion increase over the President’s request. On June 25, 2008, the House Appropriations Committee approved the bill. NASA would receive $17.8 billion, a $459 million increase over NASA’s FY 2008 budget and a $155 million increase over the President’s FY 2009 request for NASA. However, this allocation is considerably smaller than the $20.2 billion authorized in the House version of the NASA Authorization Act of 2008 (H.R. 6063, see below). The appropriations bill requires a full report on the costs of retiring the Space Shuttle by November 2009 and two shuttle flights to complete work on the International Space Station (ISS) before retirement of the Shuttle. It also includes $1.3 billion for NASA contributions to inter-agency global climate change efforts, including over $150 million for Earth science missions recommended by the National Research Council.

The allocation for the Senate Commerce, Justice, Science, and Related Agencies appropriations bill is $57.9 billion, a $4.2 billion increase over the President’s request. On June 19, 2008, the Senate Appropriations Committee approved the bill. NASA would receive $17.8 billion, a $635 million increase over NASA’s FY 2008 budget and a $200 million increase over the President’s FY 2009 request for NASA. As with the House, this allocation is considerably smaller than the $20.5 billion that the Senate Commerce, Science, and Transportation Committee authorized in the Senate’s version of the NASA Authorization Act of 2008. The appropriations bill includes: $4.5 billion for science; $500 million for aeronautics research; $3.5 billion for exploration, including $2.9 billion for the Ares I Crew Launch Vehicle and the Orion Crew Exploration Vehicle; $5.8 billion for space operations, including $2 billion for the International Space Station and $3 billion for the Space Shuttle; $130 million for education; $3.3 billion for cross-agency support; and $36 million for the inspector general.

**House Passes H.R. 6063, National Aeronautics and Space Administration Authorization Act of 2008**

On June 4, 2008, the House Science and Technology committee convened for a markup session on the NASA Reauthorization Act (H.R. 6063), a bill that was introduced by Space and Aeronautics Subcommittee Chairman Mark Udall on May 15. Original co-sponsors were Chairman Bart Gordon, Ranking Member Ralph Hall, and Subcommittee Ranking Member Tom Feeney. Chairman Gordon and Ranking Member Hall’s opening statements highlighted the bipartisan nature of the bill and its dual goal of serving as evidence of Congress’ support to NASA as well as giving clear space policy direction for the next administration. They also expounded on some of the bill’s provisions: the 2.8 percent inflationary increase over the FY 2008 budget, its encouragement of ties with the national commercial space sector, and an additional $1 billion to speed up development of the Constellation Program in an attempt to minimize dependency on Russia due to the Space Shuttle’s pending decommission.

The committee discussed three proposed amendments. Chairman Gordon’s amendment, which was approved, addresses several language clarifications – stressing the involvement of universities and other research programs – and also calls for an Outer Planets Flagship mission, an Interagency Commercial Space Launch Range Study to report to the committee by 2010, and the creation of a NASA Outreach and Technology Assistance Program. The committee voted down two additional amendments from Congressman Phil Gingrey that sought to exempt NASA from certain rules regarding the procurement of alternative energy fuels. No other amendments were proposed. The bill passed unanimously, as amended by the Gordon amendment.

The NASA Authorization Act of 2008 authorizes a total NASA budget for FY 2009 of $20.2 billion distributed between program areas as follows: science, $4.9 billion; aeronautics $853 million; exploration, $4.8 billion (including an additional $1 billion to accelerate the initial operational capability of the Orion Crew Exploration Vehicle and the Ares I Crew Launch Vehicle); education, $128 million; space operations, $6 billion (including $150 million for an additional Shuttle flight to deliver the Alpha Magnetic Spectrometer to the International Space Station and $50 million for Shuttle Transition and Retirement Activities); cross-agency support programs, $3.2 billion; and inspector general $35.5 million.

H.R. 6063 includes a number of provisions for particular programs, studies, and initiatives, including the reauthorization of the Glory Mission (which is more than 30 percent over budget and therefore must be reauthorized by Congress in accordance with provisions of the 2005 NASA Authorization Act) the development of a plan for the Deep Space Climate Observatory, the establishment of a review of NASA’s aviation safety-related research programs, steps to ensure that the International Space Station remains a productive facility for potential U.S. utilization at least until 2020, and a prohibition on lunar outpost bases being designed such that they require permanent occupation.

The measure was passed in the House by a vote of 409-15 and was referred to the Senate Committee on Commerce, Science and Transportation on June 20, 2008.
On June 24, 2008, the Senate Commerce Committee, led by Chairman Daniel Inouye (D-HI), held a markup session on its version of the FY 2008 NASA Authorization Act. In his opening remarks, the Vice Chairman Ted Stevens (R-AK), expressed Congress’ continued support of NASA.

Several amendments were adopted without discussion, including a study of the impact of current export control policies on the aerospace industry and the sense that NASA ought not to impede scientific research or its dissemination. Following the Chair and Vice Chair’s brief remarks, the bill was approved unanimously by a voice vote.

The measure authorizes a total FY 2009 NASA budget of $20.5 billion, distributed between the program areas as follows: $4.9 billion for science, $853 million for aeronautics, $3.9 billion for exploration, $128 million for education, $6.1 billion for space operations, $3.2 billion for cross-agency support and $36 million for the inspector general. It also includes an additional $1 billion for the Constellation Program to accelerate development and initial operational capabilities of the Ares 1 Crew Launch Vehicle and the Orion Crew Exploration Vehicle, $150 million for the development of a commercial crew vehicle, and $200 million for an International Space Station Research Fund.

The bill endorses U.S. space exploration policy goals, including the Moon and Mars, and adopts the National Research Council’s 2006 Decadal Survey of Civil Aeronautics as a guideline for future aeronautics spending. The bill also prohibits the space shuttle orbiters from being retired before September 30, 2010, and asks for a detailed report within 180 days on the steps and costs needed to recertify the flight-worthiness of the Space Shuttle Orbiter and associated systems for continued operations until 2015.

As in the House bill, the Senate bill eliminates the 2010 Shuttle decommission deadline provided more flights remain on the manifest, adds another shuttle flight science mission to the ISS to deliver the alpha magnetic spectrometer (AMS), requires support for the International Space Station at least until 2020, and directs NASA to request an NRC review of its aviation safety-related research programs within 18 months. It also expresses support for the Commercial Orbital Transportation Services Program and requires the establishment of a Space Shuttle Transition Liaison Office to assist those affected by the shuttle retirement.

The bill was placed on the Senate Calendar on July 16, 2008.

**SPACE STUDIES BOARD STAFF NEWS**

*Ian W. Pryke has joined the SSB as a Senior Program Officer.*

Ian Pryke retired from the European Space Agency at the end of September 2003. He is currently a Senior Fellow/Assistant Professor at the Center for Aerospace Policy Research in the School of Public Policy of George Mason University and also operates as an independent consultant. Mr. Pryke joined the European Space Research Organisation [later ESA] in 1969 working in the areas of data processing and satellite communications. In 1976 he transferred to the Agency’s Earth Observation Programme Office where he was involved in the formulation of ESA’s Remote Sensing Programme. In August 1979 he moved to the ESA Washington Office, where he was engaged in liaison work with both government and industry in the United States and Canada, taking over as Head of the Office in November 1983. Mr. Pryke is a Fellow of the American Astronautical Society, a Fellow of the American Institute of Aeronautics and Astronautics, a Member of the International Academy of Astronautics, a Fellow of the British Interplanetary Society and an Associate Founder and Trustee of the International Space University. Mr. Pryke will be working part-time with the Board on an as-needed basis.
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