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Aeronautics and Space Engineering Board News

Welcome to the latest installment of the ASEB News! This newsletter will update you on ASEB events and activities, as well as policy items of interest to the aerospace community.

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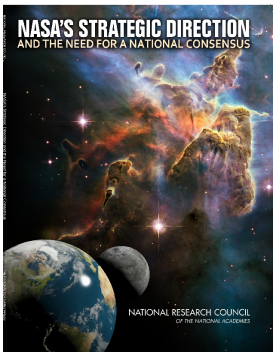
ASEB's Division Releases a New Report on NASA's Strategic Direction

On December 5, 2012, the National Research Council released a new report that examined the future of NASA and its strategic direction.

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

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

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



A copy of the Strategic Direction report can be purchased, or downloaded as a PDF document for free, from <http://www.nap.edu/catalog.php?record_id=18248>.

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Board Members

From the Chair

One of my personal favorite books is titled *Not Just Pictures on the Wall*. It is a tribute to the richness of one family's history as captured in the photos on the walls of a home. The book was written to ensure that future generations of this family knew the stories behind these otherwise obscure photos and also to ensure that the future generations learn from the trials and eventual successes of their ancestors.

I think about this allegory every time I pass the historical photos on the walls at the Keck Center, or every time I see the statuary and photos at the renovated National Academies building on Constitution Ave. in Washington DC. I know how often I pass these symbols of our country's very rich engineering past and mentally see them as just decorative "pictures on the wall," instead of what they really represent: a call and challenge to the future of engineering excellence. I assume many of you do the same thing.

I also think of this same allegory when I hear the numerous statements of support for "science and technology" or "research and development" as vital keys to the future for our economy and even our national security. Though not literally "pictures on the wall," these words have been stated so often and codified in so many places that many of us ignore their importance and fail to recognize their clarion call to make engineering and science excellence the backbone for our future.

The recent budget and fiscal challenges, especially with the new reality of "sequestration," presents opportunities for all of us who are involved in deliberating on and advising decision makers on the future to remember the legacies of the past and to use them to remind us of the possibilities of what the future can hold.

Our upcoming Spring 2013 ASEB meeting will allow the Board members to hear the from representatives of the aerospace industry, Department of Defense, and NASA on their plans for the future. Hopefully, they are working to ensure that the past does not become "just pictures on the wall"!

Lester L. Lyles
Chair, ASEB
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ASEB Calendar—Spring/Summer 2013

April 3-4, 2013	ASEB Meeting: Washington, DC.
April 5, 2013	Human Spaceflight Public and Stakeholder Opinions Panel Meeting: Washington, DC.
April 22-24, 2013	Human Spaceflight Meeting: Washington, DC.
June 18, 2013	Aeronautics Research and Technology Roundtable Meeting: Washington, DC.
June 19-21, 2013	Human Spaceflight Technical Panel Meeting: Irvine, CA.
July 24-26, 2013	Human Spaceflight Meeting: Woods Hole, MA.

For updates to the ASEB calendar, please see http://www.national-academies.org/aseb.

Committee News

Human Spaceflight Study. The Human Spaceflight Committee met in Washington, DC, on December 19 and in Stanford, CA, on January 8. The committee discussed the study background and purpose with NASA Administrator Charles Bolden, NASA Deputy Administrator Lori Garver, other officials from the Science Mission Directorate and Human Exploration and Operations Mission Directorate, congressional staff from the Senate and the House of Representatives, and a panel of experts that addressed the history, impact, challenges, and future opportunities associated with human spaceflight. The committee also carried out planning activities and developed guidance for a planned opinions panel and the already-appointed Technical Panel. This panel is assisting the study committee with technical advice, particularly with regard to facilitating a robust understanding of the technical and engineering aspects of the study. Committee co-chair Jonathan Lunine of Cornell University along with new co-chair Mitchell Daniels, Jr., of Purdue University will convene the next meeting of the committee on April 22-24 in Washington, DC. The Technical Panel, which is chaired by John Sommerer of the Johns Hopkins University Applied Physics Laboratory, held its first meeting on February 4-5 and its second meeting on March 27-28 in Washington, DC., and will hold its next meeting on June 19-21. Meanwhile, the NRC has established a second panel, the Public and Stakeholder Opinions Panel, which will assist the study committee by exploring public and stakeholder views of the motivations, goals, rationales, and possible evolution of human spaceflight. Panel chair Roger Tourangeau of Westat, Inc., will convene the first meeting of the Opinions Panel on April 5 in Washington, DC. For more information on study meetings and the members of each group, please see <http://www.nationalacademies.org/humanspaceflight>.

Study on Autonomy Research for Civil Aviation. The ASEB is forming a committee to conduct a new study on autonomy research for civil aviation. Advanced aerospace vehicles—including civil aircraft, military aircraft, and spacecraft, both manned and unmanned—incorporate autonomous systems with varying capabilities. However, the effectiveness of collaborations between humans and autonomous systems may be limited unless relevant concepts of operations take advantage of new capabilities. In addition, autonomous systems can introduce uncertainties if they are not thoroughly assessed and evaluated under a wide variety of normal and abnormal operating conditions. This study will develop a national research agenda for autonomy in civil aviation, comprised of a prioritized set of integrated and comprehensive technical goals and objectives. The elements of the recommended research agenda will be evolved from the existing state of the art, scientific and technological requirements, potential user needs, and technical research plans. The study committee will meet four times; the first meeting will likely take place in June or July.

2013 Ohio Third Frontier Innovation Platform Program. Continuing the previous work of the National Academies for the state of Ohio, a committee was established to review grant proposal applications to the Innovation Platform Program (IPP) of the Ohio Third Frontier (OTF) program for fiscal year 2013 to identify proposals that best meet the scientific, technical, and commercialization criteria of the award program. The IPP program focuses on linking the development and innovation capabilities of an already-established innovation platform and all of its resources at an Ohio college, university, or not-for-profit research institution to specific late-stage development and innovation needs of Ohio companies. This linkage must in turn lead to job creation and business opportunities in the state of Ohio through development and commercialization of new technologies, innovations, and products that will have beneficial long-term economic impacts for Ohio. The committee held its first deliberative meeting for the 2013 round of proposals on March 28-29, 2013.

The committee, chaired by T.S. Sudarshan, CEO of Materials Modification, Inc., previously reviewed proposals submitted to the 2012 IPP program, which met in April and May of 2012. The committee reported to the OTF Commission in June 2012 with its set of recommendations, which called for funding six of the submitted proposals for a total of $17,166,078 in state funding. At its July 2012 meeting, the OTF Commission voted unanimously to follow the recommendations of the committee without amendment.

The ASEB Welcomes Seven New Members

The Aeronautics and Space Engineering Board is pleased to welcome seven new members. The Board is made up of experts in aeronautics, space engineering, and complementary disciplines. Members serve staggered 2-year terms. Full biographical information for the entire Board is available at <http://www.national-academies.org/aseb>.

ARNOLD D. ALDRICH is an aerospace consultant. He joined the NASA Space Task Group at Langley Field, Virginia, in 1959, 6 months after the award of the contract to build the Mercury Spacecraft and 4 months following the selection of the seven original astronauts. He held a number of key flight operations management positions at Langley and at the NASA Johnson Space Center during the Mercury, Gemini, and Apollo programs. Subsequently, he served as Skylab deputy program manager; Apollo Spacecraft deputy program manager during the successful Apollo Soyuz Test Project with the Soviet Union; Space Shuttle Orbiter project manager; and as Space Shuttle program manager. Following the space shuttle *Challenger* accident, Mr. Aldrich was appointed director of the National Space Transportation System (Space Shuttle Program) at NASA Headquarters where he led Space Shuttle Program recovery and return-to-flight efforts. He served as NASA associate administrator for aeronautics and space technology, where he oversaw NASA efforts on the National Aerospace Plane and the High Speed Civil Transport and was responsible for program and institutional activities at the NASA research centers. Subsequently, Mr. Aldrich was appointed NASA associate administrator for Space Systems Development, overseeing the Space Station Freedom program, development of the Space Shuttle Super Lightweight External Tank, and other space system technology initiatives. In 1994, Mr. Aldrich left NASA and joined Lockheed Missiles and Space Company. With the merger of Lockheed and Martin Marietta, he joined Lockheed Martin corporate headquarters, where he oversaw X-33/Venturestar single-stage-to-orbit program activity. Later, he became director of program operations and pursued a broad array of initiatives to enhance program management across the corporation. Mr. Aldrich has received numerous honors during his career, including the Presidential Rank of Distinguished Executive and the NASA Distinguished Service Medal. He is an honorary fellow of the AIAA. Mr. Aldrich holds a B.S. in electrical engineering from Northeastern University.

BRIAN J. CANTWELL (NAE) is the Edward C. Wells Professor in the School of Engineering at Stanford University. During his tenure at Stanford, he has also served as department chair. Dr. Cantwell's research interests have included experimental and numerical investigations of variable density and reacting flows. His research has been concentrated on studies of the mixing and combustion between a flowing oxidizer and liquid droplets entrained from the surface of a melting fuel. This research has led to the identification of a new class of very fast burning fuels for application to hybrid propulsion. In the last few years he has also studied the use of nitrous oxide as a monopropellant for small space thrusters. This work has led to a new area of interdisciplinary study that joins propulsion research with environmental biotechnology. In this research the focus is on terrestrial applications where energy is derived from waste nitrogen. Dr. Cantwell was a member and deputy chair of the AGARD Fluid Dynamics Panel for supporting the aerospace technology needs of NATO. He served as a member of an executive independent review team overseeing the development of the F119, F135, and F136 engines for the Air Force Raptor and Lighting II fighters. He was given the excellence in teaching award by the Stanford student chapter of the AIAA. He is a fellow of the American Physical Society, a fellow of the AIAA, a fellow of the Royal Aeronautical Society, and a member of Sigma Xi and the NAE. He is the author of four books, including a textbook on symmetry analysis published by Cambridge Press. He holds a B.A. and B.S. from Notre Dame and an M.S. and Ph.D. in aeronautics from the California Institute of Technology.

ELIZABETH R. CANTWELL is director, Mission Development Engineering Directorate, Lawrence Livermore National Laboratory. She previously served as the deputy associate laboratory director for the National Security Directorate at Oak Ridge National Laboratory. Prior to joining Oak Ridge, Dr. Cantwell was the division leader for the International, Space, and Response Division at Los Alamos National Laboratory. Her career began in building life support systems for human spaceflight missions

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The ASEB Welcomes New Members, *cont'd*

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with the NASA. She received an M.S. in mechanical engineering from the University of Pennsylvania, an M.B.A. in finance from Wharton School, and a Ph.D. in mechanical engineering from the University of California, Berkeley. Dr. Cantwell has extensive NRC experience, including current memberships on the Space Studies Board and the Division on Engineering and Physical Sciences Board. She was co-chair of the Committee on Decadal Survey on Biological and Physical Sciences in Space; and member of the Committee on NASA's Bioastronautics Critical Path Roadmap, the Review of NASA Strategic Roadmaps: Space Station Panel, the Committee on Technology for Human/Robotic Exploration and Development of Space, and the Committee on Advanced Technology for Human Support in Space.

EILEEN M. COLLINS is the president of Space Presentations, LLC, and is a professional speaker and aerospace consultant. Colonel Collins began her career as a U.S. Air Force pilot, logging more than 6,751 hours in 30 different types of aircraft. She was a T-38 instructor pilot, a C-141 aircraft commander and instructor pilot, a T-41 instructor pilot, and a professor of mathematics at the U.S. Air Force Academy. In 1990 she was selected by NASA for the astronaut program. She has flown on four space shuttle flights in her career, including STS-63 *Discovery*, which was the first flight of the new joint Russian-American space program and the first shuttle flight to have a female pilot. STS-84 *Atlantis*, NASA's sixth shuttle mission to rendezvous and dock with the Russian Space Station Mir. STS-93 *Columbia*, which was the first space shuttle to be commanded by a woman and was highlighted by the deployment of the Chandra X-Ray Observatory. STS-114 *Discovery*, which was the return-to-flight mission during which the shuttle docked with the ISS, and the crew tested and evaluated new procedures for flight safety and shuttle inspection and repair techniques. Col. Collins also worked in Orbiter engineering support and served on the astronaut support team responsible for Orbiter prelaunch checkout, final launch configuration, crew ingress/egress, and landing/recovery. She also worked in mission control as a spacecraft communicator, served as the Astronaut Office Spacecraft Systems branch chief, chief information officer, shuttle branch chief, and astronaut safety branch chief. Col. Collins retired from the Air Force in 2005 and from NASA in 2006. She has been awarded the Defense Superior Service Medal, Distinguished Flying Cross, Defense Meritorious Service Medal, Air Force Meritorious Service Medal with one oak leaf cluster, Air Force Commendation Medal with one oak leaf cluster, Armed Forces Expeditionary Medal for service in Grenada (Operation Urgent Fury, October 1983), French Legion of Honor, NASA Outstanding Leadership Medal, NASA Space Flight Medals, Free Spirit Award, and the National Space Trophy. She received an A.S. degree in mathematics and science from Corning Community College, a B.A. in mathematics and economics from Syracuse University, an M.S. in operations research from Stanford University, and an M.A. in space systems management from Webster University.

PERETZ P. FRIEDMANN is the François-Xavier Bagnoud Professor in the Department of Aerospace Engineering at the University of Michigan, Ann Arbor. He is also the associate director of the Vertical Lift Research Center of Excellence, which is a partnership between Georgia Tech (lead university), University of Michigan, Washington University in St. Louis, and Utah State University. Prior to entering academia, Dr. Friedmann worked in Israel Aircraft Industries and was a research assistant at the Aeroelastic and Structures Laboratory at the Massachusetts Institute of Technology (MIT). He previously served as professor in the mechanical and aerospace engineering department of the University of California, Los Angeles, where he has also served as the chair of the department. Dr. Friedmann has been engaged in research on rotary-wing and fixed wing aeroelasticity, active control of vibration and noise using on blade control, hypersonic aeroelasticity and aerothermoelasticity, structural optimization with aeroelastic constraints, flutter suppression, structural dynamics, and jet engine aeroelasticity. He has published more than 320 journal and conference papers. His accomplishments have been recognized by several awards, including

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ASEB Members New to the Board in 2013

Arnold Aldrich
Aerospace Consultant

Brian Cantwell (NAE)
Stanford University

Elizabeth Cantwell
Lawrence Livermore National Laboratory

Eileen Collins
Space Presentations, LLC

Peretz Friedmann
University of Michigan

Agam Sinha
ANS Aviation International, LLC

John Stenbit (NAE)
Consultant

The ASEB Welcomes New Members, *cont'd*

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the 2013 AHS Alexander A. Nikolsky Honorary Lectureship; the AIAA Ashley Award for Aeroelasticity; the AIAA Dryden Lectureship in Research; the ASME Spirit of St. Louis Medal; the AIAA Structures, Structural Dynamics and Materials Award; the AIAA SDM Lecture Award; and the ASME/Boeing Structures and Materials Award. He is currently the editor-in-chief of the *AIAA Journal* and he is a fellow of AIAA and the American Helicopter Society. He received his B.S. and M.S. degrees in aeronautical engineering from the Technion-Israel Institute of Technology and his Sc.D. in aeronautics and astronautics from MIT.

AGAM N. SINHA is the president of ANS Aviation International, LLC. Dr. Sinha recently retired from MITRE Corporation, where he was a senior vice president, and where he was the Center for Advanced Aviation System Development (CAASD) general manager. He also directed the Federal Aviation Administration's (FAA's) federally funded research and development center. CAASD supports the FAA, the Transportation Security Administration, and international civil aviation authorities in addressing operational and technical challenges to meet aviation's capacity, efficiency, safety, and security needs. Dr. Sinha has more than 40 years of experience in aviation and weather systems. He serves on the board of trustees of Vaughn College of Aeronautics in New York and is on the Ph.D. in Aviation Advisory Board at Embry Riddle Aeronautical University. He also served as a member of the FAA's NextGen Advisory Committee and on the FAA RE&D Advisory Committee. He was elected to serve as the chairman of RTCA board of directors and the RTCA policy board. He was an elected member of the RTCA Policy Board, Air Traffic Management Advisory Committee, and the Air Traffic Management Steering Group. In the past, he has also served on the advisory committee of Lincoln Lab at MIT and of National Center of Atmospheric Research (Research Applications Programs). He is an associate fellow of AIAA. Dr. Sinha is the recipient of several awards and citations from the FAA and industry. He has more than 80 publications and has been an invited presenter to a wide range of organizations nationally and internationally. Dr. Sinha holds a B.Tech. from the Indian Institute of Technology in Bombay, India, an M.S. in management of technology from American University, and an M.S. in industrial engineering and a Ph.D. in operations research from the University of Minnesota. He served as chair of the Aviation Group of the NRC's Transportation Research Board and as chair of the Steering Committee for Oversight of FAA-Sponsored Workshops on Aviation Issues.

JOHN P. STENBIT (NAE) is a consultant. He has served as a member of the board of directors and advisory boards of various information technology companies and government agencies, such as the advisory board of the National Security Agency, the advisory board for MDA, the Strategic Advisory Group to STRATCOM, a trustee of MITRE, director of VIASAT, Loral, and Defense Group, Inc. Prior to that, he served as the assistant secretary of defense; chief information officer, Networks and Information Integration, Department of Defense; executive vice president of TRW; and principal deputy director of Telecommunications and Command and Control Systems, Office of the Secretary of Defense. Mr. Stenbit was a Fulbright Fellow and Aerospace Corporation Fellow at the Technische Hogeschool, Einhoven, The Netherlands. He is also a member of professional and scientific honorary societies, such as the NAE and Tau Beta Pi. He has been awarded the Secretary of Defense Medal for both Outstanding and Exceptional Public Service. Mr. Stenbit holds an M.S. in electrical engineering and a B.S. in engineering from the California Institute of Technology. His NRC experience includes membership on the Naval Studies Board and the Committee on Advancing Software-Intensive Systems Producibility.

NASA's Strategic Direction, *cont'd*

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

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

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

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

THE COMMITTEE ON NASA'S STRATEGIC DIRECTION

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

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

HUMAN SPACEFLIGHT

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

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Committee on Evaluating NASA's Strategic Direction

Albert Carnesale (NAE), Chair
UCLA

Ronald M. Sega, Vice Chair
Ohio State University and Colorado State University

Mark R. Abbott
Oregon State University

Jacques E. Blamont (NAS)
Centre National d'Etudes Spatiales

John C. Brock
Northrop Grumman Space Technology (retired)

Robert L. Crippen (NAE)
Thiokol Propulsion (retired)

Joseph S. Hezir
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Marcia S. Smith
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Michael S. Turner (NAS)
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National Center for Atmospheric Research

NASA's Strategic Direction, *cont'd*

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it was informed by several briefers and sources that the current planned asteroid mission has significant shortcomings.

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

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

EARTH AND SPACE SCIENCE

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

AERONAUTICS

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

TECHNOLOGY DEVELOPMENT

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

BUDGETS AND BALANCE

The funding for NASA's total budget has been remarkably level in constant-year dollars for more than a decade. However, there has been some instability at the programmatic level and the out-year projections in the President's budget are unreliable, which makes it difficult for program managers to plan activities that require multi-year planning. Put another way, although the budget may have been level over time, NASA experienced substantial program instability over the same period. Numerous times the agency initiated new programs with the *expectation* that budgets would increase to support them (a basic requirement for optimizing any development program's budget), only to have no increases emerge. Taken in aggregate, this situation has been wasteful and inefficient. Even leaving aside the funding requirements for large procurements, it is tempting to assume that if NASA officials knew to expect a flat budget they could plan better, but in several recent cases they were told (even required) to expect funding that never ultimately emerged.

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

NASA cannot execute a robust, balanced aeronautics and space program given the current budget constraints. For example, major components needed for future human exploration (including important life sciences experiments on the ISS) are not currently in the budget; high-priority science missions (including robotic planetary exploration missions that are precursors to human exploration) identified in the most recent NRC decadal survey are unfunded; and aeronautics now accounts for only

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NASA's Strategic Direction, *cont'd*

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about 3 percent of the total NASA budget. In addition, individual NASA centers are finding it necessary to selectively reduce their infrastructure or find alternative ways to support it (e.g., through external collaborations). External partnerships can be highly beneficial, especially in the current fiscally constrained environment, and may enable NASA to execute a robust and balanced aeronautics and space program without additional funds. However, coordination and integration of such activities for the overall benefit of NASA are both essential for success.

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

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

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

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

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

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

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

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

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

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NASA's Strategic Direction, *cont'd*

(Continued from page 9)

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

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

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

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

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

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

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

Recommendation: With respect to NASA centers:

The administration and Congress should adopt regulatory and legislative reforms that would enable NASA to improve the flexibility of the management of its centers.

NASA should transform its network of field centers into an integrated system that supports its strategic plan and communications and advances its strategic goals and objectives.

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

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

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

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

The committee was impressed with the quality of personnel and the level of commitment of the agency's civil service and contractor staffs

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NASA's Strategic Direction, *cont'd*

(Continued from page 10)

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

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ASEB Outreach Activities

As part of its outreach mission, the ASEB partnered with the NRC's Policy and Global Affairs Division and participated in an AIAA conference this year. Board reports and materials were exhibited at the 51st AIAA Aerospace Sciences Meeting, New Horizons Forum, and Aerospace Exposition held January 7-10, 2013 at the Gaylord Texan Resort and Convention Center in Grapevine, TX. In conjunction with the SSB, board materials were also exhibited at the American Geophysical Union fall meeting in December 2012 in San Francisco, CA. Above: PGA staff Kevin Kocur at the shared exhibit booth at the AIAA conference.

Ron Sega, Vice Chair of the Committee on NASA's Strategic Direction, Testifies before the House Committee on Science, Space, and Technology on the Future of NASA

The following is the December 12, 2012 testimony of Dr. Ron Sega, Vice Chair of the Committee on NASA's Strategic Direction, before the Committee on Science, Space, and Technology, U.S. House of Representatives. The hearing focused on the future of NASA: Perspectives on Strategic Vision for America's Space Program.

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

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

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

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

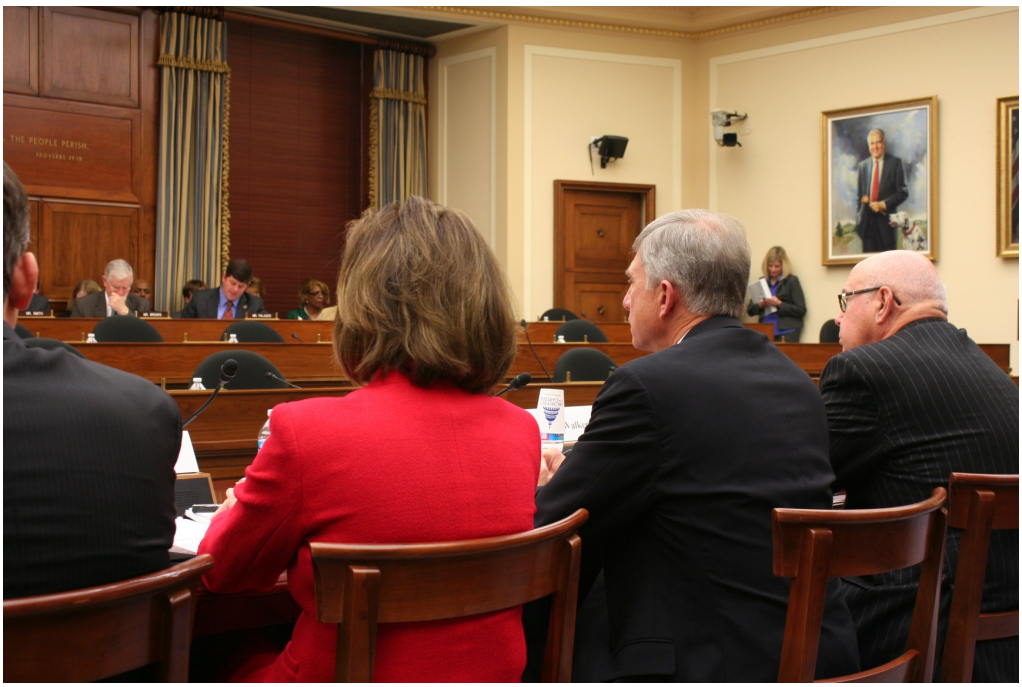
Despite these many, important activities, there remains a lack of consensus on the agency's future direction among the United States' political leadership. Without such a consensus, the agency cannot be expected to develop or work effectively toward long-term priorities. In addition, there is a mismatch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

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

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

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

Sega Testimony on the Future of NASA, *cont'd*



Ron Sega (second from right) testifies before members of the House Committee on Science, Space, and Technology on December 12, 2012.

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

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

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

- *Option 1.* Institute an aggressive restructuring program to reduce infrastructure and personnel costs to improve efficiency.

- *Option 2.* Engage in and commit for the long term to more cost-sharing partnerships with other U.S. government agencies, private sector industries, and international partners.

- *Option 3.* Increase the size of the NASA budget.

- *Option 4.* Reduce considerably the size and scope of elements of NASA's current program portfolio to better fit the current and anticipated budget profile. This would require reducing or eliminating one or more of NASA's current portfolio elements (human exploration, Earth and space science, aeronautics, and space technology) in favor of the remaining elements.

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

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Sega Testimony on the Future of NASA, *cont'd*

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attractive, given the value of each major element in NASA's portfolio.

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

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

The Role and Management of NASA's Field Centers

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

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

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

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

Recommendation: With respect to NASA centers:

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

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

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

The Role of International Cooperation

Today it is common to say that all future human spaceflight or large-scale Earth and space science projects will be international. Many U.S. leaders also assume that the United States will take the lead in such projects. However, U.S. leadership in international space cooperation requires that several conditions be met. First, the United States must have a program that other countries want to participate in, which has

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Sega Testimony of the Future of NASA, *cont'd*

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not always been the case. Second, the United States must be willing to have substantial responsibilities assumed by its partners. In the past, the approach of the United States to international partnership has too often been perceived as being based on a program conceived, planned, and directed by NASA. Third, other nations must be able to see something to gain, in other words, a reason to partner with the United States. Finally, the United States must demonstrate its reliability and attractiveness as an international partner.

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

Conclusion

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

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

Statement of Task

The National Research Council will appoint an ad hoc committee to assess whether the strategic direction of the National Aeronautics and Space Administration, as defined by the 2011 NASA strategic plan, remains viable and whether the agency's activities and organization efficiently and effectively support that direction in light of the potential for constrained budgets for the foreseeable future. In particular the committee will:

1. Consider the strategic direction of the agency as set forth most recently in 2011 NASA Strategic Plan and other relevant statements of space policy issued by the President of the United States.
2. Consider the goals for the agency set forth in the National Aeronautics and Space Act of 1958 (as amended) and the National Aeronautics and Space Administration Authorization Acts of 2005, 2008 and 2010.
3. Consider previous studies and reports relevant to this task.
4. Assess the relevance of NASA's strategic direction and goals to achieving national priorities.
5. Assess the viability of NASA's strategic direction and goals in the context of current budget expectations and stated programmatic priorities for the agency.
6. Discuss the appropriateness of the budgetary balance between NASA's various programs;
7. Examine NASA's organizational structure and identify changes that could improve the efficiency and effectiveness of the Agency's mission activities; and
8. Recommend how NASA could establish and effectively communicate a common, unifying vision for NASA's strategic direction that encompasses NASA's varied missions.

Any recommendations made by the committee will be predicated on the assumption that NASA's out year budget profile will be constrained due to continuing deficit reduction.

Metrics for Design Stability Meeting of Experts

The ASEB organized a meeting of experts for the Government Accountability Office (GAO) on February 14, 2013, in Washington, DC. The topic of the meeting was to identify metrics for assessing design stability on unique space acquisition programs. Ten experts participated in the meeting, including four independent aerospace consultants, three representatives from civil aerospace companies, a systems engineer from Air Force Space Command, the director of the Naval Center for Space Technology, and a retired program manager and special assistant to the director of the Jet Propulsion Laboratory. These experts provided feedback to the GAO regarding their plans for future assessment metrics and offered suggestions for the most appropriate metrics during each design phase. Several participants remarked afterwards that the discussion was very engaging and even fun.

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The ASEB's sister Board, the Space Studies Board (SSB), also publishes a newsletter; visit http://sites.nationalacademies.org/SSB/ssb_052298 to subscribe or to view past SSB newsletters. The ASEB's division, the Division on Engineering and Physical Sciences (DEPS), also publishes a newsletter; visit http://sites.nationalacademies.org/DEPS/DEPS_059299 to subscribe.

About the ASEB...

The Aeronautics and Space Engineering Board (ASEB) was established in 1967 "to focus talents and energies of the engineering community on significant aerospace policies and programs." In undertaking its responsibility, the ASEB oversees ad hoc committees that recommend priorities and procedures for achieving aerospace engineering objectives and offers a way to bring engineering and other related expertise to bear on aerospace issues of national importance.

The majority of ASEB studies originate with the National Aeronautics and Space Administration (NASA), particularly the Aeronautics Research Mission Directorate and the Human Exploration and Operations Mission Directorate. Some of these studies are requested by Congress in related legislation. ASEB also conducts proposal reviews for the State of Ohio's Third Millennium Program through the Ohio Department of Development and identifies experts to assist the Government Accountability Office in conducting its studies. The ASEB also has performed technical and policy studies for the Nuclear Regulatory Commission, the Defense Nuclear Agency, the Federal Aviation Administration, the National Science Foundation, the Defense Threat Reduction Agency, Air Force Space Command, the Air Force Office of Scientific Research, the National Oceanic and Atmospheric Administration, and others.