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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.

## Inside this issue



## ASEB Releases a New Report Assessing the U.S. Air Force Astrodynamics Standards

The United States Air Force does an excellent job tracking objects in orbit around the Earth, according to a new NRC study of Air Force space tracking, also known as astrodynamics. However, the NRC report recommends that the service take advantage of newly developing capabilities in the field of space tracking and increase its openness to both receiving and sharing data. The report, *Continuing Kepler's Quest – Assessing Air Force Space Command's Astrodynamics Standards*, recommends that Air Force Space Command (AFSPC) perform a strategic analysis of its space situational awareness (SSA) activities and focus on working with external partners in the creation of an upgraded open architecture.

As the space age has matured, our dependence on space systems has increased—for national security as well as civil and commercial uses. Now, more than 50 years into the space age, useful orbits are becoming more crowded with active satellites, defunct satellites, and debris. AFSPC, the U.S. Strategic Command's Joint Space Operations Center (JSpOC), and their predecessor organizations have ably served the nation and the international community, but the needs of their wide spectrum of users are increasing even as the space environment is becoming more cluttered. To address these evolving needs, it is essential that AFSPC improve the JSpOC infrastructure, modernize the software, architect the system to incorporate new algorithms and sensor data more easily, and adapt its products to meet the more demanding needs of some customers. Increasing the openness and transparency of its algorithms, research, and processes could have great value for the broader community—as well as increase user driven innovation. The Air Force needs to position the JSpOC—and its overall SSA system—to rapidly evaluate, adapt, and adopt evolving technologies to meet community needs more proactively.

While the Air Force needs to continue to support so-called "legacy systems" developed and refined over many years, the requirements for increased accuracy that space situational awareness and conjunction assessment demand would benefit from the inclusion of new types of data, as well as the technological advances made in the research efforts described above. The report recommends that the Air Force continue the development of the service-oriented architecture-based JSpOC Mission System and employ modern, modular, and extensible hardware and software architecture design practices to ensure the insertion of new technologies and accommodation of new data types while preserving backward compatibility. Because more data products would be useful to customers while tracking data and ephemerides, and maneuver planning information from operators


A copy of the Astrodynamics report can be purchased, or downloaded as a PDF document for free, from <http://www.nap.edu/catalog.php?record_id=13456>.

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## Board Members



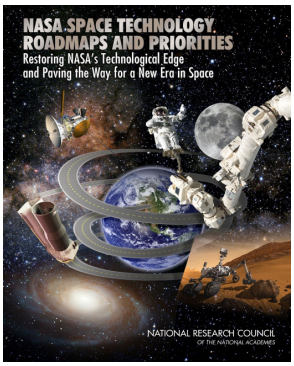
## From the Chair

As we approach the second meeting of the ASEB in 2012, it is instructive to look back over the last year to see what major activities have taken place in the ASEB's sphere of influence. At the beginning of October, during the annual meeting of the National Academy of Engineering, I listened to Dr. Mason Peck, NASA's Chief Technologist, discuss NASA's "Strategic Space Technology Investment Plan." It was very satisfying to hear the linkage between their investment plan and the ASEB/NRC report *NASA Space Technology Roadmaps and Priorities: Restoring NASA's Technological Edge and Paving the Way for a New Era in Space*, which was led by former ASEB chairman Ray Colladay. Dr. Peck credited the report for outlining a clear strategy for what NASA needs to address to maintain—or in some cases, reclaim—superiority in space engineering and technology for the future.

Similarly, the ASEB/NRC report *Recapturing NASA's Aeronautics Flight Research Capabilities* has been the focus of several congressional hearings and budget deliberations that could impact aeronautics science and technology investments for the future. NASA's Aeronautics Research Mission Directorate (ARMD) has also benefitted from a series of 'Roundtables' hosted by the ASEB this year to get immediate comments from members of the aerospace industry on their interests and challenges in the aeronautics domain. ARMD is now discussing the elements of a more detailed study by ASEB to address the research agenda that they need to gain or maintain aeronautics superiority.


A copy of the flight research report can be purchased, or downloaded as a PDF document for free, from <http://www.nap.edu/catalog.php?record_id=13384>.

The ASEB recently completed a study for the U.S. Air Force Space Command on the feasibility of a "reusable space booster." A summary of that study appears on page 4 of this newsletter. That study is part of a growing relationship between the Air Force and the ASEB to complement the current, less technical relationship between the Service and the NRC's Air Force Studies Board.




A copy of the Roadmap report can be purchased, or downloaded as a PDF document for free, from <http://www.nap.edu/catalog.php?record_id=13354>.

As some of you know, I am also the Vice Chairman of the Defense Science Board (DSB) that reports to the Secretary of Defense. This year, Secretary Leon Panetta charged the DSB to focus its annual major study on "Technology and Innovation Enablers for [military] Superiority in 2030." It is not surprising to recognize that some of the same aeronautics and space technologies identified by the recent ASEB studies can have impacts on our national security needs for the future. As I like to remind people, the science and engineering are the same; only the missions and applications are different!

The agenda for the upcoming Fall ASEB meeting will take a look at several of the technology areas that are mentioned in our previous studies—including autonomy and its role in the future Next-Gen airspace system. Autonomy has also been identified by the DSB as one of the key technology areas that is needed for future national security programs. I look forward to discussing this, along with the remainder of the important topics, at our meeting.

*Lester L. Lyles*
*Chair, ASEB*
*thelylesgroup@earthlink.net*

## ASEB and SSB Release a Popular Science Booklet on Life and Physical Sciences Research in Space

In April 2011, an SSB and ASEB committee released a report, *Recapturing a Future for Space Exploration: Life and Physical Sciences Research for a New Era,* in response to a congressional request in the FY2008 Omnibus Appropriations Act directing NASA to request from the NRC a decadal survey of life a physical sciences research in microgravity and partial-gravity environments. The report made a wide range of programmatic and technical recommendations to re-establish a robust life and physical sciences research program in space.

This past summer, the SSB and ASEB produced a companion booklet, *Research for a Future in Space: The Role of Life and Physical Sciences*. This 30-page booklet explains how unique characteristics of the space environment can be used to address complex problems in the life and physical sciences.

*Research for a Future in Space* is written for a general audience and is accessible to all readers. This booklet serves as a useful introduction to some of the issues in life and physical sciences research in space—both research that enables space exploration (life and physical sciences research that is needed to develop advanced technologies and processes) and research that is enabled by access to space (research in life and physical sciences that takes advantage of the unique characteristics of the space environment to advance scientific understanding). Issues discussed in the booklet include:

- Bone loss and nutritional needs in space
- Shifts in astronaut health during long periods in space
- Coping with confined space environments
- The roles of plant and microbial growth
- The risk of cellular and genetic changes in long-term space travel
- The nature of fluid physics in space
- Issues in fire behavior and safety: prevention, detection, suppression
- The matter of materials and the relativity of time
- Essential technologies for space suits
- Living off the land: using in situ materials


A copy of *Research for a Future in Space* can be purchased, or downloaded as a PDF document for free, from <http://www.nap.edu/catalog.php?record_id=13450>.

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## ASEB Calendar—Fall 2012

The ASEB is holding its fall meeting on **November 8-9, 2012, in Irvine, CA at the National Academies' Beckman Center.** The meeting will include two topical focus sessions—one on alternate fuels and one on technology development on the International Space Station. Other ASEB activities and committees will have meetings this fall and winter but have not yet scheduled those dates. For more information on the Board meeting agenda and for updates on other committee meetings, please visit http://www.nas.edu/aseb.

*We were deeply saddened to learn of the passing of ASEB member Capt. Alan G. Poindexter, Naval Postgraduate School, on July 1, 2012. We extend our condolences to his family and friends.*

## Committee for the Reusable Booster System: Review and Assessment

David Van Wie, Chair
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Edward Bock
*Lockheed Martin Space Systems*

Yvonne Brill (NAE)
*Independent Consultant*

Allan Burman
*Jefferson Consulting Group, LLC*

David Byers
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Robert Dickman
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Pol Spanos (NAE)
*Rice University*

Mitchell Walker
*Georgia Institute of Technology*

Ben Zinn (NAE)
*Georgia Institute of Technology*

A copy of the Reusable Booster Systems report can be purchased, or downloaded as a PDF document for free, from <http://www.nap.edu/catalog.php?record_id=13534>.

# A New ASEB Report Finds Reusable Booster System Business Case Incomplete; Underlying Technologies Show Significant Potential

The Reusable Booster System (RBS) concept is an unmanned launch vehicle with an autonomous guidance and control system, designed to address one of Air Force Space Command's identified long-term science and technology challenges: providing full-spectrum launch capability at dramatically lower cost than the evolved expendable launch vehicle presently employed. The RBS consists of a reusable first stage and an expendable second stage. The first stage is designed to return to the launch site following stage separation so it can be recovered and reused in future launches.

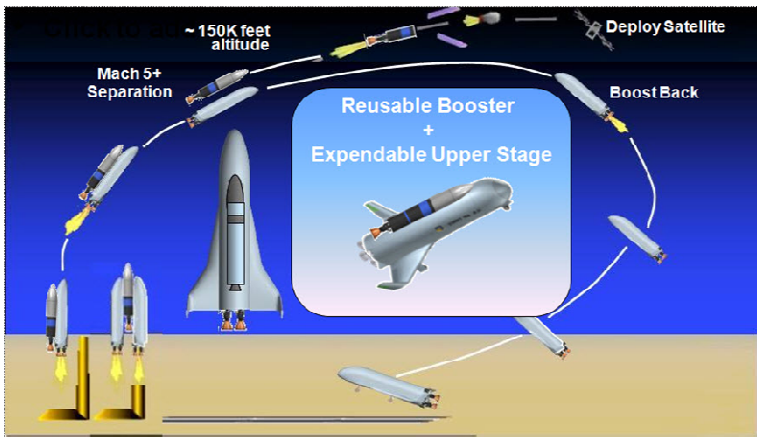
A new report issued by the ASEB on October 15, 2012 concluded that, due to uncertainties in the business case and yet-to-be mitigated technology risks associated with the RBS concept, it is currently premature for Air Force Space Command to invest substantially in developing RBS. However, the report strongly endorses the continued research and advanced technology development needed for future launch systems and concludes that reusability remains an option in the future.

Tasked with reviewing and assessing the RBS concept and business case, the authoring committee found that the business case is not complete, as it does not adequately account for new entrant commercial launch providers, the impacts of single source providers, the Air Force's need for independent launch sources to meet the requirement for assured access to space, and the technical risks. Furthermore, the committee determined that a phased approach to the project should be employed and that the initiation of each new phase should not be undertaken until the technical risks in the previous phase have been mitigated and the overall business case have been reviewed.

The report stresses that the Air Force should continue to develop necessary launch system technologies independent of any decision to proceed with RBS development, as these innovations will be required to support future decisions regarding RBS and may also be applicable to alternative launch system concepts. These technologies consist of:

1. Demonstrating that the first stage can perform a maneuver following stage separation that will reverse its velocity vector at a hypersonic, high altitude condition allowing it to return to the launch site;
2. Developing a reusable liquid-oxygen rich/ hydrocarbon fuel staged-combustion booster rocket;
3. Equipping the booster with an integrated vehicle health monitoring system to collect diagnostic information so that the vehicle controls can adapt to its current health status and guide post-flight inspections so as to reduce refurbishment time and effort between launches; and
4. Developing an adaptive guidance and control system to cope with system anomalies and improve reliability.

The committee's report was prepared by 15 experts with considerable experience in the architecture of launch vehicles, cost analysis, launch procedures, aerothermodynamics, and the design and production of liquid rocket engines. The committee, chaired by Dr. David Van Wie of Johns Hopkins University Applied Physics Laboratory, carried out the review and assessment of the RBS program in three meetings, during which presentations were made by the Air Force, NASA, and commercial aerospace organizations. General William Shelton, Commander of the Air Force Space Command, and his staff were briefed on the study results in Colorado Springs, CO, on October 9, 2012 and the report was released to the public on October 15, 2012.



## Committee News

**Human Spaceflight Study.** Following the transfer of funds from NASA to the NRC, the human spaceflight study commenced on August 1, 2012, and the committee recruitment process is currently underway and making good progress. William J. Perry of Stanford University and Jonathan Lunine of Cornell University have recently been approved by the National Academies to serve as co-chairs of the study. Prior to the start of the actual study, a number of activities were carried out under a separate initiation task, including outreach; collection of research materials; the identification of skill sets, knowledge, and perspectives critical to the study; and the broad solicitation of names as well as the review of qualifications for an extensive set of committee candidates. Outreach activities conducted in this period included a discussion session held during the Global Space Exploration Conference in Washington, DC, in which representatives from several international space agencies discussed the perspectives of their citizens and governments on the value, rationale, and future direction of human space exploration.

**NASA's Strategic Directions.** The ASEB's parent division, the Division on Engineering and Physical Sciences, has been asked to conduct a comprehensive, agency wide assessment of NASA's strategic direction and activities. The ASEB and the SSB are conducting the study for the division. The Committee on NASA's Strategic Direction recently held its fifth and final meeting in California and is drafting its report. In addition to its regular meetings, committee members have also visited all of the NASA field centers, learning about the work they perform and their perspectives on the future of the agency. The committee's final report is expected to enter review soon, with delivery scheduled for after the November elections.

**2012 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) competition of the Ohio Third Frontier (OTF) Program for fiscal year 2012 to identify proposals that best meet the scientific, technical, and commercialization criteria of the award program. The IPP competition focuses on linking the development and innovation capabilities of an already-established innovation platform and all 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, chaired by T.S. Sudarshan, CEO of Materials Modification, Inc., held two meetings, one in April 2012 and one in May 2012, where the committee interviewed applicant teams from 13 finalist proposals. 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.

## Solar and Space Physics Decadal Survey Steering Committee

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*NOAA Space Weather Prediction Center*

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Edward C. Stone, NAS
*California Institute of Technology*

# New Decadal Survey in Solar and Space Physics is Released

The second decadal survey in solar and space physics was released on August 15, 2012 by the Space Studies Board, in cooperation with the ASEB. *Solar and Space Physics: A Science for a Technological Society* presents a prioritized program of basic and applied research for 2013-2022 that will advance scientific understanding of the Sun, Sun-Earth connections and the origins of space weather, and the sun's interactions with other bodies in the solar system. This 18-month effort by more than 85 solar and space physicists and space system engineers lays out four scientific goals for the period 2013-2022, along with guiding principles and recommended actions. The recommended actions include completion of projects in NASA and the National Science Foundation's (NSF's) current program, creation of a new "mid-scale" projects line at NSF, augmentation of NASA and NSF "enabling" programs, and acceleration and expansion of NASA's Heliophysics Explorer Program. For later in the decade, the report recommends beginning new moderate-size NASA missions to address high-priority science targets, and a multiagency initiative to address pressing needs for improved forecasts of space weather and predictions of its impacts on society.

The committee established four overarching scientific goals for the period 2013-2022:

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

To achieve these scientific goals, the report recommends adhering to the following guiding principles:

- To make transformational scientific progress, the Sun, Earth, and heliosphere must be studied as coupled systems.
- To understand the coupled system requires that each subdiscipline be able to make measurable advances in achieving its key scientific goals.
- Success across the entire field requires that the various elements of solar and space physics research programs—the enabling foundation comprising theory, modeling, data analysis, innovation, and education, as well as ground-based facilities and small-, medium-, and large-class space missions—be deployed with careful attention to both the mix of assets and to the schedule (cadence) that optimizes their utility over time.

Taking into consideration cost, schedule, and complexity, the report provides a number of research recommendations to realize its four primary goals. It also considers challenges that could impede achievement of the recommended program, including budget issues, the necessity to coordinate activities across multiple agencies, and the limited availability of appropriately sized and affordable space launch vehicles.

The report recommends that support should continue in the near term for the key existing program elements that comprise the Heliophysics Systems Observatory and for successful implementation of programs in advanced stages of development.

Additional recommendations include establishing a new, integrated multiagency initiative, called DRIVE, that will more effectively exploit NASA and NSF scientific assets. The DRIVE initiative is made up of five components:

1. **D**iversify observing platforms with microsatellites and mid-scale ground-based assets;
2. **R**ealize scientific potential by sufficiently funding operations and data analysis;
3. **I**ntegrate observing platforms and strengthen ties between agency disciplines;

A copy of the solar and space physics decadal survey can be purchased, or downloaded as a PDF document for free, from <http://www.nap.edu/catalog.php?record_id=13060>.

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## Solar and Space Physics Decadal Survey Released

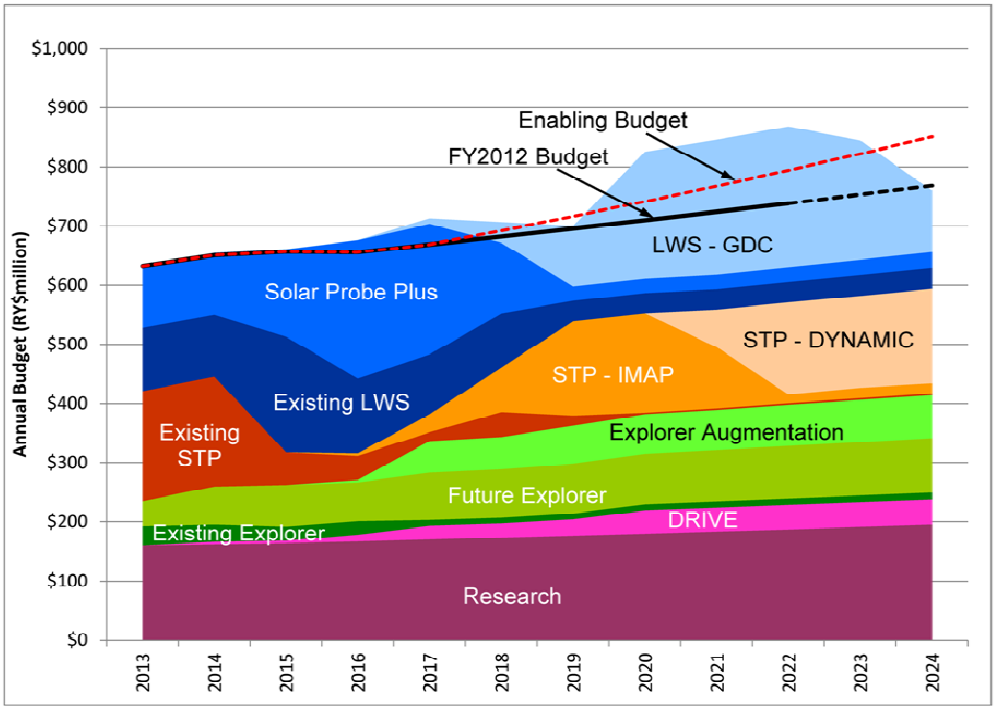
(Continued from page 6)

4. **V**enture forward with science centers and instrument and technology development; and

5. **E**ducate, empower, and inspire the next generation of space researchers.

The report recommends that NASA should also accelerate and expand the Heliophysics Explorer program, which provides frequent flight opportunities to enable the definition, development and implementation of mission concepts. Augmenting the current program by $70 million per year, in fiscal year 2012 dollars, would restore the option of mid-size Explorers and allow them to be offered in alternation with small explorers every 2 to 3 years. As part of the augmented Explorer program, the report recommends NASA support regular selections of Missions of Opportunity, which would allow the research community to respond quickly and to leverage limited resources with interagency, international, and commercial flight partnerships. For relatively modest investments, such opportunities can potentially address high-priority science aims identified in this survey.

The recommended new moderate- and large-class mission starts later in the decade would investigate space physics at the edge of heliosphere where the Sun's influence wanes, the effects of processes in Earth's lower atmosphere on conditions in space, fundamental questions related to the creation and transport of plasma in Earth's ionosphere and magnetosphere, and how the Earth responds globally to magnetic storms from the Sun.




The committee's recommended program for NASA Heliophysics Division for the years 2013-2024 is shown by category in the figure above. The plan restores the medium-class Explorers and, together with small-class Explorer missions and Missions of Opportunity, achieves the recommended minimum mission cadence. The committee's recommended new starts in the restructured Solar-Terrestrial Probes (STP) mission line and the Living With a Star Program (LWS) also begin in the latter part of the decadal survey interval. The solid black line in the figure indicates the funding level from 2013 to 2022 provided to the committee by NASA as the baseline for budget planning, and the dashed black line extrapolates the budget forward to 2024. After 2017, the amount increases with a nominal 2% inflationary factor. The red dashed "Enabling Budget" line includes a modest increase from the baseline budget starting in 2017, allowing implementation of the survey-recommended program at a more efficient cadence that better meets scientific and societal needs and improves optimization of the mix of small and large missions. From 2017 to 2024 the Enabling Budget grows at 1.5% above inflation. If necessary, GDC implementation could be stretched (at some cost) to conform to the projected funding profile.

### Where's the report summary?

Looking for a more extended summary of one of our reports? On the report's page on the National Academies Press website (such as <http://www.nap.edu/catalog.php?record_id=12202>), scroll down a little bit to a section called "Free Resources." There, in a box titled "Download Free," you will see a link called "PDF Summary." Click the link to download the full summary in PDF format. Many reports also have a link here for a "Report in Brief", a one- or two-page summary of the report.

### Where's the report?

Each of our reports is also available in its entirety in PDF format from the National Academies Press website. Each report highlighted in this newsletter has its corresponding NAP website listed (such as <http://www.nap.edu/catalog.php?record_id=12202>). On the report's page, click on the button that says "Download free PDF" and follow the instructions to download the full report.

You can browse or search the NAP website at <http://www.nap.edu> for other ASEB titles.

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*NASA*

Edward Yarbrough
*Honeywell International*

## The ASEB Convenes the Third Meeting of the Aeronautics Research and Technology Roundtable

The ASEB's Aeronautics Research and Technology Roundtable held its third meeting on August 2-3, 2012, in Washington, DC. The Roundtable convenes senior-most representatives from industry, universities, and NASA to define and explore critical issues related to NASA's aeronautics research agenda. Chaired by Boeing Chief Technology Officer John Tracy, the 25-member Roundtable includes a broad range of executives, entrepreneurs, and experts representing airframe and engine manufacturers, general aviation companies, academia, industry associations, and other federal agencies. The Roundtable meets several times a year and does not create any written reports or products. Its purpose is to facilitate candid dialogue among participants, foster greater partnership among the NASA-related aeronautics community, and, where appropriate, carry awareness of issues to the wider public.

At its August meeting, the Roundtable's task was to assist NASA in developing a white paper guiding the agency's aeronautics research program. NRC staff and NASA will be discussing future items for the Roundtable to consider at upcoming meetings.

For more information about the Roundtable, including information about upcoming meetings, please visit: <http://sites.nationalacademies.org/DEPS/ASEB/DEPS_061276>.

## Wesley Harris, Chair of the ASEB's Flight Research Committee, Testifies before the House Subcommittee on Space and Aeronautics on NASA's FY2013 Aeronautics Budget

*The following is the April 26, 2012 testimony of Dr. Wesley Harris, Chair of the ASEB's Committee to Assess NASA's Aeronautics Flight Research Capabilities, before the Subcommittee on Space and Aeronautics, Committee on Science, Space and Technology, U.S. House of Representatives. The hearing focused on the FY2013 NASA Aeronautics Research Mission Directorate budget.*

Mr. Chairman, Ranking Member Costello, members of the committee, colleagues, I am Wesley Harris, Chair of the National Research Council's Committee to Assess NASA's Aeronautics Flight Research Capabilities. It is a 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 2011 NASA asked the NRC to undertake a study of NASA's flight research capabilities. I am here to report on the results of that study.

Our committee consisted of members of industry and

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Dr. Wesley Harris (left), chair of ASEB's Committee to Assess NASA's Aeronautics Flight Research Capabilities, and Dr. John Tracy (right), chair of the ASEB's Aeronautics Research and Technology Roundtable, testified before the House Science Committee on April 26, 2012, on NASA's Aeronautics Budget for FY2013. *Photo by Lindsay Meyers, House Science Committee.*

## Harris Testimony on NASA's Aeronautics Budget, continued

(Continued from page 8)

academia, former NASA aerospace officials, UAV designers, test pilots, and even an Apollo moonwalker with a strong interest in flight research. We met multiple times throughout 2011, visiting NASA centers involved in flight research and hearing from numerous NASA and industry representatives. We received extensive cooperation from the agency for which the committee is very grateful.

Many people may be aware that unmanned aerial vehicles (UAVs), sometimes referred to as uninhabited aerial systems, are a vital part of America's national security and a highly dynamic part of our aerospace industry, something where the United States remains the world leader. What few people realize, however, is that during the 1990s NASA played a major role in making this happen by supporting the development of multiple advanced UAV designs, thereby spawning the industry that is so active today. This was an industry where the United States was behind, and now it leads. That was NASA's flight research in action, not in the distant past, but relatively recently and in my personal opinion NASA should receive recognition for this achievement.

Currently NASA often calls for "game changing" ideas. Our committee concluded that in order to achieve game changing results in aeronautics, the agency has to conduct useful, efficient aeronautical flight research. However, in the course of the study, we found that NASA is only conducting a low level of flight research and we concluded that they should, and they can, do much more.

Flight research is only one part of a healthy aeronautics research enterprise, but it is a vital part. A common analogy is that aeronautics research is like a three-legged stool. One leg is simulation and modeling, taking advantage of powerful computing technology. Another leg of the stool is wind tunnel testing. The third leg is flight research—flying aircraft to test new theories, test new combinations of technologies, validate existing computer and mathematical models, and demonstrating and validating technologies and concepts so that they can be adopted by commercial and military operators and manufacturers. Remove one leg of the stool and it topples over. A commonly held misconception is that flight research is something that comes at the end of a research program; however, in many cases it is necessary in the middle of a program in order to validate aspects of the research. For instance, it is very common in the aeronautics world to update sophisticated computer simulations based upon data collected by actually flying a vehicle.

Since the middle of the last decade NASA has dramatically reduced its flight research to focus more on ground-based investigations and activities in what NASA describes as its "fundamental" aeronautical research. Today we see the results of that development. If you visit a

From right: Dr. John Tracy, Dr. Wesley Harris, Ms. Marion Blakey, and Dr. Jaiwon Shin testifying before the House Science Committee on April 26, 2012, on NASA's Aeronautics Budget for FY2013. *Photo by Lindsay Meyers, House Science Committee.*

NASA center involved in flight research, you will see very few programs that involve actual flying. In the committee's opinion, most flight research today can be characterized as limited in scope, such as putting a new structure on or under the wing of an existing airplane such as an F-15, or flying a small-scale UAV. There are almost no unique flight research vehicles currently flying, that is aircraft specifically designed for research such as the famed X-planes. NASA has tremendous personnel and capital resources, however the committee concluded that it is not using those resources to conduct the kind of flight research we would expect would inspire future generations of aeronautical engineers, or that is required to make major advances on the frontiers of knowledge and functionality.

Our committee recommended that NASA should start from two to five focused, integrated, higher risk, higher payoff, and interdisciplinary programs with total budgets of $30 to $50 million (per vehicle/program) over three years. In order to achieve progress for fundamental aeronautics as well as other relevant related military requirements, we recommended that these priority focused projects should be drawn from the high priority research areas identified by the 2006 NRC decadal survey of civil aeronautics.

The committee concluded that additional funding for aeronautics was not a prerequisite for NASA being able to begin to implement this recommendation provided that the agency phases out the majority of its lower-priority aeronautics activities—a move that we believe would facilitate implementing two to three new vehicles. If aeronautics receives additional funding, NASA could implement three to five

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## Harris Testimony on NASA's FY2013 Aeronautics Budget, continued

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new vehicles. Naturally, there is a tradeoff between the size of the individual projects and the number the agency could pursue—that is, more, smaller projects versus fewer, larger projects. As stated, the committee estimated that to make significant progress in each of the selected areas, the $30 million to $50 million (total over three years) would be the appropriate scope for such activities. An ambitious UAV project could be built at the lower end of that range, while a more ambitious piloted vehicle could be built at the higher end. For example, Sikorsky's piloted X-2 helicopter, which recently won the Collier's Trophy, cost approximately $50 million.

Our committee specifically mentioned the Collier's Trophy as an aspirational goal for NASA's aeronautics program. The Trophy is awarded for outstanding aeronautics achievement in the previous year. NASA has won the Trophy in the past and is capable of doing so again. Although our report does not recommend this, I personally think that NASA should consider approving new projects on the basis of their ability to compete for such a prestigious prize. The agency should aim high in its ambitions.

The committee also recommended that NASA's aeronautics research projects have a defined "path to flight"—essentially a roadmap that indicates how they intend to conduct actual flight research. The lack of such roadmaps leads to many current projects getting canceled before they can be pursued to the flight phase and their progress is subsequently lost. In addition, by failing to define such a path, many projects never even get started because their advocates determine that they can never get sufficient funding to conduct flight research. Thus, many promising research subjects are never explored.

Our committee notably did not recommend more money for NASA's aeronautics program. However, we do believe that it could benefit from additional funding—if NASA's budget shifted only one percent of its total funding to aeronautics research it would enable substantial new research in several vital areas of prime national interest. But in the current fiscal environment we also believe that the aeronautics program could benefit from reordering its priorities, establishing focused goals, and eliminating lower-priority research programs if flight research is to be a priority activity.

The committee selected three areas of NASA aeronautical research as case studies. We selected these subjects because NASA has already made substantial progress in them—a fact the agency should be commended for—and we believed each of these areas are at the point where transitioning to flight research could produce significantly more progress. The detailed case studies enabled the committee to assess the essential strengths and weaknesses, challenges and opportunities in NASA aeronautical flight activities. These areas were environmentally responsible aviation, supersonics, and hypersonics.

Environmentally responsible aviation essentially involves developing highly fuel efficient aircraft that produce little noise. This is important because of rising fuel prices, and the encroachment of residential areas upon airports, as well as the increasingly strict noise and pollution regulations that are being imposed upon aircraft, particularly in Europe. If the United States is to remain a world leader in commercial aviation, we must be able to sell competitive aircraft to airlines around the world. The committee found that NASA could make substantial research leaps by developing a large scale aircraft that integrated many relevant technologies. Such aircraft might look radically different than those that people fly in today. NASA could develop this technology in concert with other government agencies as well as commercial industry.

In the area of supersonics, NASA is on the cusp of making a substantial leap that could create an entire industry of small supersonic passenger jets, just as NASA helped to create the modern UAV industry in the late 1990s. The agency has already performed considerable research into so-called low-boom technology, or aircraft that do not produce the loud sonic boom that prevents supersonic aircraft from operating over most of the United States. If NASA were to build a research aircraft, it could demonstrate that such vehicles could fly across the United States without producing loud sonic booms and with only a slight increase in fuel burn. This could put the United States at the forefront of such development.

Hypersonics is another area where NASA has developed great expertise over the years. We found that the agency could better focus its efforts on development of a hypersonic vehicle capable of high-speed, relatively long duration flight. Naturally, NASA would support DoD research in this area.

During the course of our study, the committee spoke with various representatives from industry, including people from Boeing, Lockheed Martin's Skunk Works, Aurora Flight Sciences, and other companies. Despite what I believe is a common perception that aeronautics is so mature that NASA's research role should be limited, that is NOT an attitude that we encountered within industry. Quite to the contrary, the industry representatives we talked to believed that NASA can play a vital role in helping to develop technologies that industry is too risk averse to address. They want NASA to be involved, doing what NASA does best, and what they believe industry cannot do.

When answering the question of "why should NASA be involved in aeronautics research, particularly conducting flight research," the committee concluded that industry in these economic times cannot and will not take on the full cost risk of moving technologies from the laboratory to operations. NASA's founding charter tasks the agency to help with this process. NASA's role is to develop requirements for the next research vehicles and then work with industry to build and test those aircraft.

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## Harris Testimony on NASA's FY2013 Aeronautics Budget, continued

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Some of the potential areas that industry said NASA could help with are:

- Collecting high-altitude atmospheric data that could be used in the design of new high-altitude UAVs. This includes characterization of high-altitude turbulence, which is fundamental to understanding the aeroelastic effects on flight vehicles as well as characterizing the radiation environment at high altitudes, which could affect avionics systems. NASA currently has assets such as the U-2 and WB-57 high-altitude aircraft, as well as balloons, capable of gathering this data.
- Conducting research on pilotless commercial aircraft, perhaps starting with unpiloted cargo aircraft.
- Conducting research into electric aircraft propulsion and electric vehicle subsystems.
- A larger-scale experimental aircraft to explore ERA and N+3 technologies. This would be bigger than the X-48C, with a wingspan of perhaps 40 to 50 feet (compared to 21 feet for the X-48B). The cost of such a vehicle, according to an aerospace company with experience producing similar vehicles, could be in the range of $25 million to $60 million.
- Initiating programs to develop low-cost ($30 million to $50 million) innovative flight research vehicles, to demonstrate new technologies such as lift fan and fan-in-wing for a high-speed VTOL, or to gather useful data in the transonic or supersonic flight regimes.
- Conducting research on autonomous systems and the interaction between human operators and autonomous systems.
- Conducting research on hybrid propulsion, especially electric, quiet powered, distributed lift concepts, especially those enabled by hybrid electric systems, and quiet trans- and supersonic small aircraft for both commercial and military applications.

NASA cannot and should not go it alone. Our report contained the following recommendation:

**Recommendation**: NASA aeronautics should aggressively pursue collaboration with DOD, FAA, the U.S. aerospace industry, and international aeronautics research agencies. NASA should adopt management practices to facilitate effective collaboration and treat external organizations as customers and partners. NASA leadership should develop a formal process for regularly soliciting input from the U.S. aerospace industry and universities as well as key government agencies to assure the relevancy of its flight research programs to national needs.

Although NASA is currently involved in numerous cooperative efforts, our committee heard from other government agency representatives that NASA often participates in cooperative efforts, but does not always bring its own resources to the table. In order to maximize its effectiveness, NASA should provide funding for all its cooperative efforts.

Despite an outstanding history of NASA-led aeronautics flight research successfully transitioning to the U.S. aerospace industry, NASA could be more effective in identifying and communicating these accomplishments to key stakeholders within industry, government and academic institutions. One aspect of communication to stakeholders is the effective dissemination of technical data to relevant aerospace researchers after a flight research program is completed. Prior National Advisory Committee on Aeronautics (NACA—NASA's predecessor) reports, generated more than 50 years ago, are rich resources of information for the aerospace community to this day and are relatively accessible. However, more recent NASA aeronautics flight research programs have generated useful data that is relatively inaccessible to aerospace engineers and scientists. This led our committee to the following recommendation:

**Recommendation**: NASA aeronautics should become the nation's repository of flight research data and flight test results and should make these archival data readily accessible to key stakeholders—the engineers and scientists in industry, academia, and other government agencies. NASA should also require principal investigators in flight research projects to publish their results and provide funding for them to do so.

NASA's flight research inventory is a mix of vehicles that are currently distributed across NASA centers, including Dryden Flight Research Center, Glenn Research Center, Ames Research Center, and Langley Research Center. NASA may be able to achieve greater efficiencies by designating a single center as the primary flight research center for the agency. We recommended that NASA study this possibility, fully aware that some flight research aircraft may be best supported at locations around the country. However, the current level of flight activity is so low that consolidation may free up valuable funds.

NASA is a highly capable organization with many excellent people in the area of aeronautics research. The contributions the agency has made and continues to make in aeronautical research are significant and in my personal opinion the importance of the work done by NASA's Aeronautics Research Mission Directorate should be more broadly recognized. However, we were asked to look at the area of flight research and having conducted our study we believe that we as a nation have an opportunity to accomplish much more in this research area of prime national importance if given the opportunity. If we give NASA the tools to take flight, we believe—I believe—they will soar.

Thank you for the opportunity to testify. I would be happy to answer any questions the Subcommittee might have.

## Astrodynamics Report, continued

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would be useful to the JSpOC, the Air Force should create an open-architecture, application programming interface to facilitate the bidirectional exchange of a wider array of data, algorithms, and documentation with a growing number of external entities.

While the Air Force is becoming more open, there is still work to be done, and the report recommends that the Air Force should review its information distribution policies and work with external customers toward the objectives of (1) more freely sharing data products, algorithms, and documentation and (2) ensuring that such information is timely, accurate, useful, and actionable. The committee also found that many data and algorithms produced by the Air Force are difficult to disseminate to the wider community because of classification or International Traffic in Arms Regulations (ITAR). The report recommends a reevaluation of these restrictions, especially regarding distribution of propagated ephemerides and collision probability. JSpOC algorithm and model developers should fully communicate the results of their work and their development activities, such as in appropriate peer-reviewed publications and conferences, so that users gain greater insight into and understanding of the underlying assumptions associated with catalog activities.

The evolution and expansion of the Air Force's mission responsibilities and the growth of the orbital population are both likely to continue and to lead to increased demands on the AFSPC workforce. The report recommends that the Air Force review its personnel policies and practices so that DOD staffing levels and expertise are budgeted for and maintained in SSA mission-critical functions, including the JSpOC. Additionally, as the Air Force upgrades the JSpOC hardware and software systems, it should automate routine processes to the extent possible to minimize manual intervention, decrease operational workload, and reduce possibilities for error.


***Recapturing NASA's Aeronautics Flight Research Capabilities,* reissued and dedicated to Neil A. Armstrong—aviator, educator, and pioneer in aeronautics—1930-2012, is available from the Aeronautics and Space Engineering Board (aseb@nas.edu).**

# *News from the National Academies*

## C.D. (Dan) Mote Jr. Nominated To Be Next NAE President

The National Academy of Engineering (NAE) 2013 nominating committee unanimously recommended C.D. (Dan) Mote Jr., past president and Regents Professor of the University of Maryland (UMD), to stand as the sole candidate for the NAE presidency. NAE members will vote in March 2013 to elect a new NAE president to a 6-year term beginning July 1.

## Neil Armstrong 1930-2012

Neil Armstrong, the first person ever to step onto another planetary body, died on August 25, 2012 . His words spoken during the 1969 Apollo 11 mission to Earth's moon—"That is one small step for (a) man, one giant leap for mankind"—instantly became a part of history. Those few words from the Sea of Tranquility, NASA stated on its website, were the climactic fulfillment of the efforts and hopes of millions of people and the expenditure of billions of dollars.

A member of the National Academy of Engineering, Armstrong contributed his expertise to several Academies projects, and most recently served as a member of the Aeronautics and Space Engineering Board's Committee to Assess NASA's Aeronautics Flight Research Capabilities. The report of this committee, *Recapturing NASA's Aeronautics Flight Research Capabilities,* has been reissued in his honor.

His NASA obituary can be found at http://www.nasa.gov/topics/people/features/armstrong_obit.html.

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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.