Hearing of the House Committee on Science, Space, and Technology
Subcommittee on Space and Aeronautics Hearing

"A Review of NASA's Exploration Program in Transition:
Issues for Congress and Industry"

Wednesday, March 30, 2011 - 10:00 AM – RHOB 2318

Testimony of Dr. Scott Pace, Director, Space Policy Institute,
Elliott School of International Affairs, The George Washington University

Thank you, Mr. Chairman, for providing an opportunity to discuss this important topic. The transition away from the Space Shuttle to a new generation of vehicles for human access to space is perhaps the most critical task facing the U.S. space program today. In this regard, it is appropriate and timely that the Committee examines the accomplishments of the Constellation program and prospects for a Space Launch System and Multi-Purpose Crew Vehicle as contained in the most recent 2010 NASA Authorization Act.

Specifically, the Committee has posed four questions that I will address in turn:

1. Has the use of existing Constellation contracts to prioritize the work on the Space Launch System been an efficient and effective approach?

The FY 2010 Emergency Supplemental Appropriations bill contained a provision co-sponsored by Senator Richard Shelby (R-AL) and Robert Bennett (R-UT) that said:

> "Provided further, that notwithstanding any other provision of law or regulation, funds made available for Constellation in Fiscal Year 2010 for 'National Aeronautics and Space Administration Exploration' and from previous appropriations for 'National Aeronautics and Space Administration Exploration' shall be available to fund continued performance of Constellation contracts, and performance of such Constellation contracts may not be terminated for convenience by the National Aeronautics and Space Administration in Fiscal Year 2010."

Approval of this provision was, in my view, an understandable response to the many uncertainties faced by the Congress last year. Two previous NASA Authorizations, in 2005 and 2008 had approved clear efforts to transition the Space Shuttle, extend operations of the International Space Station, and explore beyond Earth orbit. As part of the Fiscal Years 2007, 2008, and 2009 NASA budgets, the Constellation program became a consistent and well-understood approach for implementing exploration objectives. The Obama Administration had sought to cancel the Constellation program and terminate existing contracts with the Fiscal Year 2011 NASA budget. However, this dramatic change of course was not accompanied by a clear explanation of what would replace Constellation. In particular, there were no concrete explanations of how the transition

away from the Space Shuttle would be implemented, support for the International Space Station assured, or human explorations beyond Earth orbit conducted.

In light of this situation, the requirement to use existing Constellation contracts was an effective and prudent measure. It is difficult to say that such a requirement was efficient as it would almost certainly have been preferable if the Administration and Congress could have found a common approach on human space exploration before the release of the FY 2011 President's Budget Request. It is the prerogative of any Administration to review and reorder priorities for NASA, and it is possible to imagine a dialogue with Congress that would have resulted in a reordering of the Constellation program (e.g., placing greater emphasis on demonstrating new technologies). However, the disruption that would have resulted from the wholesale cancellation of the Constellation contracts would have been harmful to the U.S. space industrial base. The existing contractors would have certainly been harmed and other potential contractors would not have benefited if for no other reason than the time it would have taken to define, compete, and award new contracts. The lack of a clear alternative to the Constellation program meant that contract cancellation at that time would largely have resulted in a waste of public funds.

Continuation of the Constellation contracts enabled time for industry, Congress, and I suspect NASA, to think more carefully about next steps. This enabled continued development of the Orion Crew Exploration vehicle to include a successful pad abort demonstration and completion of the ground test article. It enabled completion of the five-segment Ares solid rocket booster, including static test firings, continued structures technology testing with a successful shell-buckling test, and continued development assembly of the J2-X upper stage engine and A-3 test stand – the only new cryogenic engine development for the United States.

2. How do NASA's recent efforts to transition from the Constellation program to the Space Launch System and Multi Purpose Crew Vehicle align with the recommendations of the Columbia Accident Investigation Board?

One of the most important observations from the Columbia Accident Investigation Board (CAIB) for steps to take after the Space Shuttle was the following:

> "It is the view of the Board that the previous attempts to develop a replacement vehicle for the aging Shuttle represent a failure of national leadership. The cause of the failure was continuing to expect major technological advances in that vehicle. With the amount of risk inherent in the Space Shuttle, the first step should be to reach an agreement that the overriding mission of the replacement system is to move humans safely and reliably into and out of Earth orbit. "

Furthermore, the CAIB offered the admonition that:

> "The design of the system should give overriding priority to crew safety, rather than trade safety against other performance criteria, such as low cost and

> reusability, or against advanced space operation capabilities other than crew transfer."

To these ends, the Constellation Ares 1 set a goal for probability of loss of crew (PLoC) in excess of 1:1000 with design estimates for reaching over 1:2800. In comparison the Space Shuttle's PLoC has been estimated at less than 1:150. No other vehicles, including the Ares V design and existing Evolved Expendable Launch Vehicles (EELVs), are expected to exceed the 1:1000 standard. This is not to say they cannot do so in the future, but only after accumulating flight heritage comparable to the Shuttle solid rocket motors or the Russian Soyuz.

With regard to the CAIB's recommendations, NASA effort to transition from Constellation program designs to the Space Launch System can be seen as incomplete and arguably inadequate. They do not appear to make progress toward the CAIB's central recommendation on dramatically improving crew safety. The transition of Orion to a Multi-Purpose Crew Vehicle looks to be in better shape, in particular with progress on a Launch Abort System, but it is the fully integrated combination of launch vehicle, crew vehicle, and escape system that must be considered.

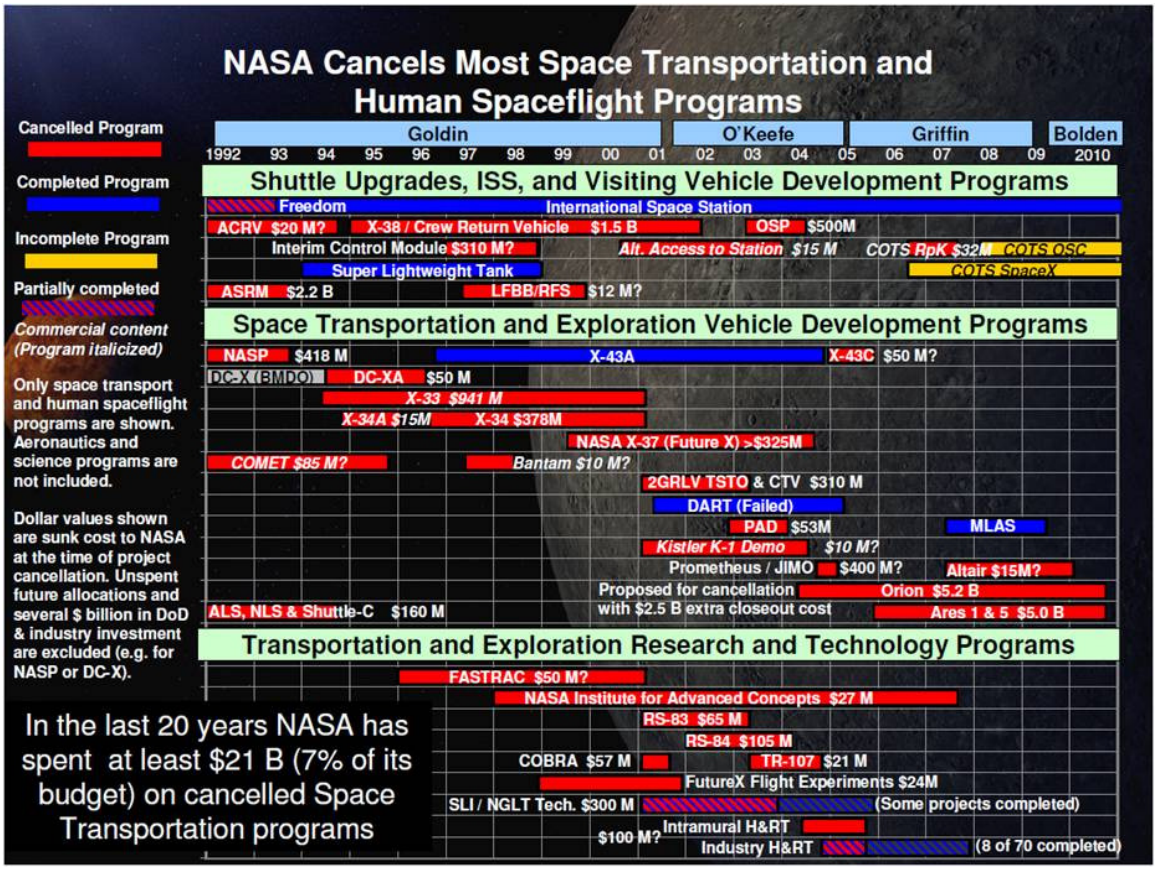
The CAIB also commented on the need for stability of purpose in the development of new launch vehicles:

> "NASA plans to make continuing investments in "next generation launch technology," with the hope that those investments will enable a decision by the end of this decade on what that next generation launch vehicle should be. This is a worthy goal, and should be pursued. *The Board notes that this approach can only be successful: if it is sustained over the decade; if by the time a decision to develop a new vehicle is made there is a clearer idea of how the new space transportation system fits into the nation's overall plans for space; and if the U.S. government is willing at the time a development decision is made to commit the substantial resources required to implement it."*

As discussed in response to the following questions below, none of the conditions cited by the CAIB appear to be met by current proposals before the Congress.

3. What are the greatest risks to the aerospace industrial base and workforce associated with the transition from Constellation to the Space Launch System program?

The greatest risks are those arising from policy instability and the lack of a basis for predictable decision-making by NASA and industry. Such instability has very real costs as the chart below indicates:

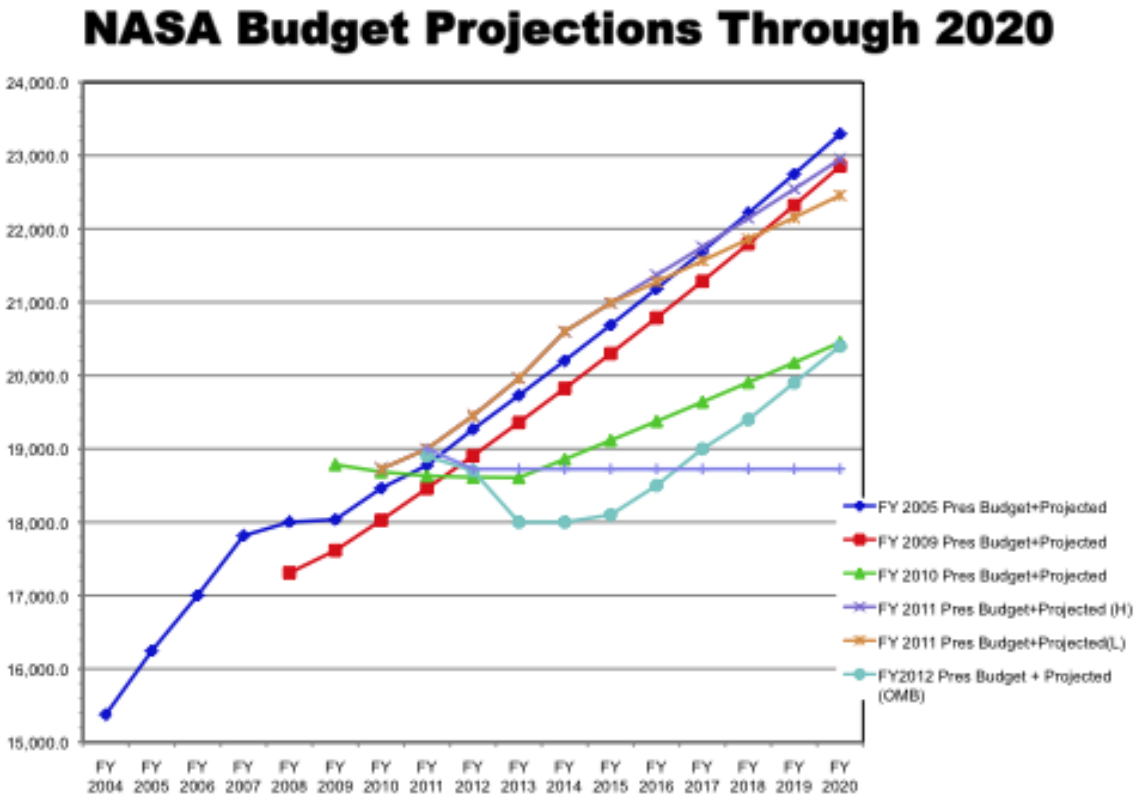


The history of U.S. human spaceflight over the past two decades is one of continual turbulence with occasional episodes of progress. There are many sources of policy instability – some internal to NASA, some embedded in the relationship between successive Administrations and Congresses. The net result has been a lack of human-rated launch vehicle and spacecraft development experience while Shuttle operations continued and various R&D programs came and went. Unlike the scientific community at NASA, there was not a steady progression of spacecraft development programs in which both NASA and industry could gain and maintain expertise. The rebuilding of expertise was occurring on the Constellation program, notably with the Ares 1-X flight test, but that progress has not been followed up on.

NASA's plans prior to Ares I-X for testing of the Ares I rocket and Orion spacecraft could be characterized as largely ground test programs that would have avoided committing to actual flight until a predominant amount of risk had been retired. The experiences from Ares I-X and Pad Abort I helped teach the NASA-industry teams how to 'finish' a product and fly it – an experience base that would have led to a more prominent role for incremental flight testing as a means of risk reduction if funding had continued.

Through its budget proposals, the current Administration has contributed to policy instability for NASA as a whole, not just in human space flight. The chart below shows proposed and projected top-line NASA budgets back to FY 2005 when the Vision for

Space Exploration was proposed and through 2020 when the first human return to the Moon was planned.

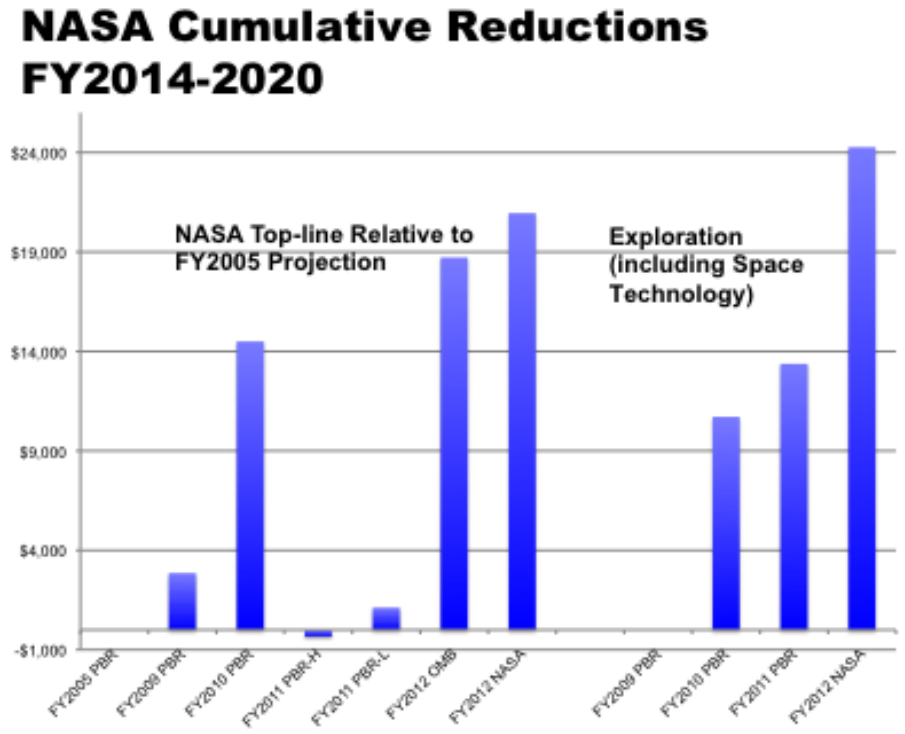


The FY 2005 NASA budget projection was expected to remain flat in terms of purchasing power and thus it increased at only 2.4% in the out years. The FY 2009 NASA budget shows that NASA received slightly less funding that it had planned for in FY 2005 and this resulted in the schedule slip of Ares 1/Orion first flight to 2014 or possibly later. The first Obama Administration budget for FY 2010 projected a large reduction, due to placing $3 billion in exploration funding "on hold" while reviews of NASA's human spaceflight programs occurred. In addition to those funds directly affected, the projection of out year spending was reduced to 1.36%. If inflation levels experienced by NASA were more than that, the agency would experience a decline in real purchasing power.

In the FY 2011 proposal for NASA, the Administration added funds back such that the NASA top line returned to where it would have been in continuing the spending levels of the Bush Administration. However, the composition of spending had changed significantly, with exploration spending dropping and science and technology-related spending increasing sharply. In FY 2012, the pendulum continues to swing with NASA expecting at best a flat budget in nominal terms (and thus a reduction in real terms) while OMB seems to envision even sharper reductions in the near term with possible restoration of some funds in the out years.

With the kinds of programmatic and budget redirection that NASA has received in recent years, it is hard to expect a positive outcome for workforce productivity or the health of the space industrial base.

The chart below show the cumulative reductions experienced in the overall NASA budget and the exploration budget respectively for the years FY 2014-2020. This was the time period that had been targeted for conducting the first human missions beyond low Earth orbit since Apollo. Even if all of the Administration's space technology funding is counted toward "exploration," the cumulative reductions in future support for human space exploration remain dramatic.



4. Can you suggest some key indicators that would help Congress judge the success of NASA's transition efforts?

There are many ways to monitor transition efforts, from workforce plans, to completion of hardware milestones. However, the most important consideration has always been people, both inside NASA and in industry. Government and industry cannot have coherent workforce transition plans if they cannot define what skill mixes they need today or in the future. Skill mixes cannot be defined absent a clear understanding of government roles and responsibilities (e.g., what work is to be done in-house and what will be contracted out) and a stable set of mission requirements that are part of a larger architecture and exploration strategy.

The lack of a U.S. focus on human lunar return and an associated architecture is one of the most serious programmatic gaps that make transition planning difficult. Efforts to

find a feasible and attractive mission to a Near Earth Object (NEO) have not been successful and likely await the completion of a more complete survey of such objects. Sending humans to Mars remains too technically difficult and expensive at our current level of development. The Moon was and continues to be the logical focus for efforts to move humans beyond low Earth Orbit as well as being vital to future commercial developments. For example, the logistics requirements of a sustained lunar base offer perhaps the only near term source of significant new demand for cargo mass to low Earth orbit (LEO). Commercial service to the International Space Station (ISS) is an important first step, but ISS supply needs are limited and unlikely to attract major new investment by itself. If the Administration is truly supportive of stimulating commercial space transportation beyond LEO then it needs to consider where future demand might come from. It's not a question of choosing between government and commercial approaches, but of government first and then commercial in a well-considered transition.

This does not mean that the Constellation approach to the Moon is the only one possible – one can envision precursor missions to Lagrangian points in the Earth-Moon system and tele-presence experiments prior to a human landing. In a similar vein, one can imagine missions to NEOs as part of precursor efforts to send human to orbit Mars. The crucial point is that individual missions should not be one-time highly dangerous stunts, but should be careful steps in the continual expansion of human deep-space capabilities that can address important human exploration questions. The international space community has developed a lunar architecture as part of a large Global Exploration Strategy with strong U.S. technical participation. We should consider making greater use of international partners through existing international mechanisms to create a more rational approach for our own plans.

The Congress should be looking for updated workforce transition plans, with reports on the identification of key skills and how they will be retained. Next, the Congress should look to ensure that NASA and industry are creating and strengthening their internal "intellectual capital" for developing new human spaceflight capabilities. This can be most directly observed in through frequent and increasingly ambitious tests and flights of actual hardware. Finally, the Congress should be asking for progress on the definition of an internationally accepted human space exploration architecture that supports U.S. national space policy goals and principles.

Summary

The design, development, and operation of major space systems reflect the strategic engineering capacity of the United States. This capacity is being tested today by the technical and managerial challenges of developing new human-rated space systems. The transition away from the Space Shuttle and towards new human space flight capabilities, while assuring independent U.S. access to the International Space Station, is the most immediate and critical task for U.S. human spaceflight.

Planning for and successfully executing this transition has been made significantly more challenging by the policy, programmatic, and budget instability of the past two years. As

a result, the United States does not have at present a plausible architecture and strategy for conducting human missions beyond LEO for the next two decades. In addition, a plausible architecture and approach for international cooperation in human space flight beyond the International Space Station no longer exists. This has been a particular problem for many countries that had started development of lunar robotic and human space flight plans based on the Constellation program structure.

Major policy questions remain unanswered that complicate transition efforts. Perhaps foremost among them is whether or not there is a need for independent U.S. government human access to space, and if not, the identification of those entities upon which we are willing to depend for such access. In my view, the U.S. government should have its own means for ensuring human access to space even as it makes increasing use of commercial services or international partners. Just as a diversified portfolio needs bonds as well as stocks, a "public option" is an important and crucial part of a diversified portfolio for a strategic national capability like human space flight. Complete reliance on commercial or international services is an excessively risky approach that can deter innovation in those areas as they become "too important to be left alone." It was the existence of Constellation that enabled prudent risk taking in commercial cargo services and contemplation of eventual procurement of commercial crew services.

A corollary question is: what is the proper role of NASA for the human expansion into space, given NASA's disparate functions as "innovator and technology developer" vs. "designer/developer/smart buyer" of new systems, and "system operator" vs. "service customer"? The Administration's proposals for human space flight appear to have a clear policy theme – that there is *no compelling need* for a U.S. government human space flight program and that all necessary objectives and risks can be meet by private contractors using government funding with reduced if not minimal oversight. The technical complexities and risks of human space flight make it an activity distinct from buying normal commercial goods and services. A policy approach that pretends or assumes that it is not distinct is unlikely to succeed – just as the unrealistic flight rates planned for the Shuttle in the 1970s or the large commercial markets for EELVs in the 1990s did not succeed.

The government has several proper roles to play in the next generation of human space exploration and those roles can and should evolve in parallel over time. It is time to push carefully for greater reliance on commercial cargo services to the International Space Station. It is subsequently possible to define a path for commercial crew services that operate in addition to, but not to the exclusion of, U.S. government capabilities. To fully rely on commercial or government approaches, to the exclusion of the other, would place all human space flight by the United States at risk, public and private.

Thank you for your attention. I would be happy to answer any questions you might have.

Scott Pace

Dr. Scott Pace is the Director of the Space Policy Institute and a Professor of Practice in International Affairs at George Washington University's Elliott School of International Affairs. His research interests include civil, commercial, and national security space policy, and the management of technical innovation. From 2005-2008, he served as the Associate Administrator for Program Analysis and Evaluation at NASA.

Prior to NASA, Dr. Pace was the Assistant Director for Space and Aeronautics in the White House Office of Science and Technology Policy (OSTP). From 1993-2000, Dr Pace worked for the RAND Corporation's Science and Technology Policy Institute (STPI). From 1990 to 1993, Dr. Pace served as the Deputy Director and Acting Director of the Office of Space Commerce, in the Office of the Deputy Secretary of the Department of Commerce. He received a Bachelor of Science degree in Physics from Harvey Mudd College in 1980; Masters degrees in Aeronautics & Astronautics and Technology & Policy from the Massachusetts Institute of Technology in 1982; and a Doctorate in Policy Analysis from the RAND Graduate School in 1989.

Dr. Pace received the NASA Outstanding Leadership Medal in 2008, the U.S. Department of State's Group Superior Honor Award, *GPS Interagency Team*, in 2005, and the NASA Group Achievement Award, *Columbia Accident Rapid Reaction Team*, in 2004. He has been a member of the U.S. Delegation to the World Radiocommunication Conferences in 1997, 2000, 2003, and 2007. He was also a member of the U.S. Delegation to the Asia-Pacific Economic Cooperation Telecommunications Working Group, 1997-2000. He is a past member of the Earth Studies Committee, Space Studies Board, National Research Council and the Commercial Activities Subcommittee, NASA Advisory Council. Dr. Pace is a currently a member of the Board of Trustees, Universities Space Research Association, a Corresponding Member of the International Academy of Astronautics, and a member of the Board of Governors of the National Space Society.