

## Lessons for the Future of Human Space Flight

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As we contemplate the future of the Nation's human space flight program at this critical juncture, I would like share my own thoughts with the Committee based on almost 40 years of experience working in the space program--from JPL scientist in 1968 to NASA Associate Administrator for the Office of Space Science in 1993-1998, to continuing passionate advocate ever since. I think there are eight high-level lessons learned from past experience.

First, the US needs to develop its next deep space transportation system to go to the Moon and beyond. We have only this one chance to develop a new post-Shuttle space transportation system; the next won't come for many decades. The US needs to demonstrate to itself as much as to others that it remains the leader in space exploration and is the partner of choice for international space enterprises. To do that the US must show its clear intention to go beyond where it has been before. Even while reestablishing the capability to do what it did before, the US must have its sights set squarely on going beyond the Moon to deeper space destinations. Establishing this goal will demonstrate that the US intends to remain in front of any nation now considering duplicating what NASA did 40 years ago. Missions to near-Earth asteroids or Sun-Earth libration points can be done before the need to develop lunar landing and support hardware. Any new transportation system should be readily capable of flights to destinations beyond the Moon. *The ultimate long-term driver should be to send humans to Mars sometime in the next 50 years and this feature of the original 2004 Vision for Space Exploration needs to be reemphasized.*

Second, absent unlimited resources as in the Apollo years, Presidentially imposed completion dates are deadly. Why? Because NASA will sacrifice everything to meet them. There are only three controllable variables to engineering development: cost, schedule and performance. With both schedule and agency budget fixed, as costs inevitably rise for a technologically challenging development the only alternatives are to compromise system performance or to cannibalize funds from other agency enterprises. NASA has done both as the funding required to meet the President's "Moon by 2020" directive has not been forthcoming from the Office of Management and Budget. This deadline must be deleted in favor of direction to proceed at a pace commensurate with available budget.

Third, specification of a particular destination will limit the capability of the transportation system to go to other destinations. Another result of the President's "Moon by 2020" direction is NASA's singular focus on the Moon as a destination. The driving requirements for Constellation are all lunar-derived and only passing attention has been given to requirements for other destinations. Constellation is now a point design for the Moon that will be costly to adapt or rebuild for other destinations

beyond. The President should not only delete the deadline from his directive but also the emphasis on the Moon as a destination.

Fourth, cost must be a foremost consideration. For Apollo cost was no object. This “build it and the money will come” culture has carried over into Space Shuttle, Space Station and lingers on in Constellation. NASA seems unable to approach human space flight from a cost-limited perspective. NASA’s strong focus on setting and meeting engineering requirements for Constellation without an equal focus on cost of development and operations is the program’s Achilles Heel. The directive to land on the Moon by 2020 is not achievable given the agency’s current limited out-year budget, costs for Constellation development, and the looming requirement to support the Space Station beyond 2015. The best approach to lower cost and sustained development is to leverage existing space transportation infrastructure to the maximum.

Fifth, the next generation of deep space human missions should be conducted as an international enterprise. Space is no longer exclusively a US and Russian playing field, it has become international. Neither is space any longer a singular token for national pride but also a tool for international diplomacy and cooperation. The US can no longer isolate itself in vainglory, but must embrace new partners towards mutual benefit to enable space exploration enterprises that individual nations including our own would find difficult or impossible to undertake unilaterally. Much of the heavy lifting in establishing precedent for international partnerships has been undertaken by the International Space Station. A significant result is that while the US and Russia could each have separate human space flight programs they don’t--they only have a joint program. The ISS sets the stage for continuing beyond earth orbit using an expanded ISS partnership as a springboard both in the engineering and political senses.

Sixth, the rationale for the program must be articulated for the public. A question from the very first public commenter at the Committee’s opening meeting hit the mark. “NASA’s focus is on engineering and vehicles. There has been no explanation of what we are going to do when we get there. What’s the plan and are we going beyond the Moon? You won’t get public interest and sustain it until we know these things.” NASA has proven itself technically competent but publicly impotent in spite of many studies internal and external that have articulated the imperatives for exploring space. Ironically, the Administration’s 2004 Vision for Space Exploration did it quite well in very few words. The Committee would serve the Nation and its space program well by expressing these imperatives for the public and its representatives in the Congress and the Administration.

Seventh, NASA must provide the public with a long deep space exploration plan that includes well-defined milestone accomplishments. For any long-term exploration enterprise to be sustainable through multiple Administrations it must lay out the game plan with a set of specific milestones as did Apollo (although as much on the fly as strategic) so that the public can understand the play-by-play and follow the march to

the goal posts. Such a plan is necessary not only for public support but also so that each new Administration does not feel the need to reinvent the program. *NASA's space exploration program remains a source of inspiration and future hope for the Nation's young people, especially in trying times that challenge the American Dream. The Nation must show its public that it can do better than repeat what it did 40 years ago.*

Eighth, robotic exploration must be supported as a means to explore where humans cannot go and to assist humans to go where they can. NASA's human and robotic exploration enterprises have evolved as cultures apart. Each is wary of the other and not without reason. The robotic scientific enterprise has always been under threat from the insatiable demands of an inadequately funded human space flight enterprise, while the high performance of robotic missions appears a threat to human space flight exacerbated by the excoriating remarks of scientists who fail to understand the rationale for human space flight. Both enterprises are vital to the agency and vital to each other. Robotic exploration should have equal priority with human exploration and both should have incentives to support the other.