

**U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON SPACE**

Next Steps in Human Exploration to Mars and Beyond

Tuesday, May 21, 2013
2:00 p.m. – 4:00 p.m.
2318 Rayburn House Office Building

Purpose

The purpose of this hearing is to examine possible options for the next steps in human space flight and how these options move the United States closer to a human mission to Mars and beyond. In particular, the Committee will explore whether the Administration's proposed asteroid rendezvous mission is a better precursor for an eventual manned mission to Mars compared to Apollo-like follow-on missions to return to the Moon.

Witnesses

- Dr. Louis Friedman, Co-Lead, Keck Institute for Space Studies Asteroid Retrieval Mission Study and Executive Director Emeritus, The Planetary Society
- Dr. Paul Spudis, Senior Staff Scientist at the Lunar and Planetary Institute
- Dr. Steve Squyres, Goldwin Smith Professor of Astronomy at Cornell University
- Mr. Doug Cooke, Owner, Cooke Concepts and Solutions

Overarching Questions

1. Is the proposed Asteroid Retrieval Mission (ARM), a lunar landing mission, or another mission better as a precursor for an eventual human mission to Mars?
2. What things could we learn and capabilities would we develop from a Moon landing that we could not learn from the proposed Asteroid Retrieval Mission?
3. How do different destinations or missions affect a strategic approach with our potential international partners as well as technical architectures?

Background

Following the Space Shuttle *Columbia* accident in February 2003 and the subsequent investigation into its cause, President George W. Bush announced a new "Vision for Space Exploration" on January 14, 2004, to reinvigorate and redirect NASA's human exploration program beyond the International Space Station. The plan focused on the next steps for low-Earth orbit and beyond Earth orbit. It also provided a generalized vision that the Administrator could use to "implement an integrated, long-term robotic and human exploration program structured with measurable milestones and executed on the basis of available resources, accumulated experience, and

technology readiness.”¹ The plan included four main goals and objectives: to implement a sustained and affordable human and robotic program to explore the solar system; to extend human presence across the solar system, starting with a human return to the Moon by the year 2020, in preparation for human exploration of Mars and other destinations; to develop the innovative technologies, knowledge, and infrastructures both to explore and to support decisions about the destinations for human exploration; and promote international and commercial participation in exploration to further U.S. scientific, security, and economic interests.² The Constellation Program was born out of the New Vision for Space Exploration and the work for this new program began with NASA’s budget request for fiscal year 2005.

After his appointment as Administrator in April 2005, Dr. Mike Griffin ordered a review of NASA’s exploration architecture called the “Exploration Systems Architecture Study” (ESAS) to carry out this vision. After the completion of the study, NASA began, with the concurrence of Congress, to restructure the exploration program with an emphasis on acceleration of the development of capabilities to ferry astronauts to the International Space Station.³ The study recommended the development of a Space Shuttle-derived launch architecture⁴ and an exploration vehicle that was capable of carrying cargo and crew to the Space Station as well as crew to the Moon and Mars.⁵ Congress codified the majority of the ESAS plan in the National Aeronautics and Space Administration Reauthorization Act of 2005, understanding the milestone schedule was based primarily on the ability to “go-as-we-can-afford-to-pay.”

In 2009, President Obama ordered a review of the Constellation program and acting NASA Administrator Chris Scolese established the “Review of U.S. Human Spaceflight Plans Committee” (the Commission), also known as the “Augustine Commission” for its chairman, Norman R. Augustine. The charter for the Commission called for an “independent review of ongoing U.S. human space flight plans and programs, as well as alternatives, to ensure the Nation is pursuing the best trajectory for the future of human space flight—one that is safe, innovative, affordable, and sustainable.”⁶ The Commission released its final report on October 22, 2009.⁷

The Commission found that “the ultimate goal of human exploration is to chart a path for human expansion into the solar system,”⁸ but that “since Constellation’s inception, the program has faced a mismatch between funding and program content”⁹ and “[d]ifferences between the original Constellation program planning budget and the actual implementation budget, coupled with technical problems that have been encountered on the [programs], have produced the most significant overall impacts to the execution of the Constellation program.”¹⁰ The Commission offered five options for the future of the human exploration program, two of which complied with

¹ National Aeronautics and Space Administration-*The Vision for Space Exploration, February 2004*. Retrieved at http://www.nasa.gov/pdf/55583main_vision_space_exploration2.pdf

² *Ibid.*

³ National Aeronautics and Space Administration Exploration Systems Architecture Study (pg 59). Retrieved at http://www.nasa.gov/pdf/140632main_ESAS_02.pdf

⁴ *Ibid.* 3 at pg 717

⁵ *Ibid.* 3 at pg 714

⁶ Charter of the “Review of U.S. Human Spaceflight Plans Committee”. retrieved at http://www.nasa.gov/pdf/354415main_Charter%20-%20Signed%20-%20Clean.pdf

⁷ Final Report of the “Review of U.S. Human Spaceflight Plans Committee”. Retrieved at: http://www.nasa.gov/pdf/396093main_HSF_Cmte_FinalReport.pdf

⁸ *Ibid.* 7 at pg 9

⁹ *Ibid.* 7 at pg 58

¹⁰ *Ibid.* 7 at pg 59

the FY2010 budget profile of the Obama Administration for the Constellation program,¹¹ however, neither of these two options would “permit human exploration to continue in any meaningful way.”¹²

As a result of this review, President Obama offered a budget for fiscal year 2011 that proposed to cancel the Constellation program.¹³ Later that same year, Congress authorized some of the changes to the human exploration program sought by the President¹⁴ as outlined in a speech on April 15, 2010. In this speech at the Kennedy Space Center he revealed his strategy for the future of human exploration which canceled a return mission to the Moon, saying, “I understand that some believe that we should attempt a return to the surface of the Moon first, as previously planned. But I just have to say pretty bluntly here: We’ve been there before... Early in the next decade, a set of crewed flights will test and prove the systems required for exploration beyond low Earth orbit. And by 2025, we expect new spacecraft designed for long journeys to allow us to begin the first-ever crewed missions beyond the Moon into deep space. So we’ll start -- we’ll start by sending astronauts to an asteroid for the first time in history. By the mid-2030s, I believe we can send humans to orbit Mars and return them safely to Earth. And a landing on Mars will follow.”¹⁵

Current Law and National Space Policy

On June 28, 2010 the President announced a new National Space Policy which outlined priorities as well as principles and objectives for the extension of human presence deeper into the solar system.

Although both President Obama and the Administrator have repeatedly said the United States will not be going back to the Moon,^{16,17} current law, derived by numerous NASA Authorization Acts over the last decade, requires lunar missions as destinations or at the very least, precursors to other missions. The NASA Authorization Act of 2005 directed NASA to:

*...establish a program to develop a sustained human presence on the Moon, including a robust precursor program, to promote exploration, science, commerce, and United States preeminence in space, and as a stepping-stone to future exploration of Mars and other destinations.*¹⁸

Additionally, the 2005 Act required the Administrator to:

*...implement an exploration technology development program to enable lunar human and robotic operations consistent with section 101(b)(2) including surface power to use on the Moon and other locations;*¹⁹

¹¹ http://www.nasa.gov/pdf/345955main_8_Exploration_%20FY_2010_UPDATED_final.pdf. Note the significant change in the budget projection for the Constellation program from the FY 2010 budget profile on page EXP-2.

¹² *Ibid.* 7 at pg 16

¹³ President’s Budget Request for the National Aeronautics and Space Administration, Fiscal Year 2011. Retrieved at <http://www.nasa.gov/news/budget/2011.html>

¹⁴ Public Law 111-267: National Aeronautics and Space Administration Reauthorization Act of 2010

¹⁵ Speech by President Obama at Kennedy Space Center on April 15, 2010

http://www.nasa.gov/news/media/trans/obama_ksc_trans.html

¹⁶ *Ibid.*

¹⁷ Oral Testimony of Administrator Charles Bolden before the House Science, Space and Technology Subcommittee on Space, April 24, 2013.

¹⁸ 51 USC 20302

¹⁹ 51 USC 70502

Following the reorganization of the Constellation program, Congress endorsed additional requirements for NASA's human exploration program in the 2008 Act, including a requirement for the Administrator to create a "Stepping Stone Approach" to exploration:

In order to maximize the cost-effectiveness of the long-term exploration and utilization activities of the United States, the Administrator shall take all necessary steps, including engaging international partners, to ensure that activities in its lunar exploration program shall be designed and implemented in a manner that gives strong consideration to how those activities might also help meet the requirements of future exploration and utilization activities beyond the Moon. The timetable of the lunar phase of the long-term international exploration initiative shall be determined by the availability of funding. However, once an exploration-related project enters its development phase, the Administrator shall seek, to the maximum extent practicable, to complete that project without undue delays.²⁰

At present, there is no plan for NASA to return humans to the Moon. According to NASA Administrator Bolden, there is no money in the Administration's budget for such a mission.²¹

Next Steps

As NASA prepares to take the next steps in human exploration of the solar system there are many unanswered questions about the correct path to Mars and beyond. The Apollo Program was not a straight shot to the Moon; it included several precursor missions to test new capabilities and gain experience on the way to the Moon including Projects Mercury and Gemini. In much the same way, NASA will need to acquire new capabilities to travel to Mars and beyond.

The two most commonly discussed possibilities for precursor missions to Mars involve manned missions to the Moon or an asteroid.

Lunar Mission

The "Vision for Space Exploration" called for a return to the Moon by 2020 as a stepping stone to other locations and NASA has continued various lunar science projects such as the Lunar Reconnaissance Orbiter (LRO) and the Gravity Recovery and Interior Laboratory (GRAIL). The Constellation program was ideally suited for landing on the Moon with the inclusion of a lunar lander called the "Altair" in the "system of systems" approach to exploration. Since the cancellation of the Constellation program, there is no longer a lunar lander under development.

There are several compelling reasons for using the Moon as a training ground and test bed to prepare for more complex missions. Landing on the Moon would develop technical capabilities for landing on and launching from a large celestial body, something NASA has not done for more than four decades.²² Establishing a semi-permanent or permanent presence on the Moon such as the lunar outpost referenced in the NASA Authorization Acts of 2005 and 2008,²³ would give astronauts an opportunity to work and live in an environment radically different from Earth, in much the same way explorers on Mars would. Ultimately, operating on another planet will require

²⁰ 51 USC 70504

²¹ Oral Testimony of Administrator Charles Bolden before the House Science, Space and Technology Subcommittee on Space, April 24, 2013.

²² The last time humans landed on the moon was Apollo 17 on December 7, 1972.

²³ 51 USC 70505

training and preparation, the Moon seems like a logical place to do this training. “On the international front, there appears to be continued enthusiasm for a mission to the Moon.”²⁴

Asteroid Mission

The National Space Policy issued by President Obama in April 2010, and released formally later that year, envisioned sending humans to an asteroid by the year 2025 beyond lunar orbit into “deep space.”^{25,26} The National Research Council issued a report last December which stated that “[t]he 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.”²⁷

The Administration proposed a revised asteroid mission with the FY2014 budget request. The mission concept proposed by the Administration features a robotic capture and redirection of a small near Earth asteroid (NEA) to a deep retrograde lunar orbit for astronauts to visit rather than sending Astronauts to an asteroid in deep space.

The proposed Asteroid Retrieval Mission (ARM) has multiple stages. First, using the Near Earth Observation Program will identify an appropriate asteroid passing near Earth based on size, composition, and orbit while simultaneously developing advanced solar electric propulsion technology. NASA will then need to develop and build a robotic probe to launch to the target asteroid in time to intersect its orbit. This probe will then “dock” with the asteroid while also stabilizing its rotation and ferry it to a retrograde lunar orbit. Finally, NASA will launch a crewed Orion capsule aboard the SLS in order to rendezvous and explore the asteroid, potentially on the initial manned flight of the new vehicle and capsule.

The mission concept is based on a study by the Keck Institute for Space Studies (Keck Study) at the California Institute of Technology in partnership with the Jet Propulsion Laboratory. The Keck Study estimated a mission of this size and scope would cost approximately \$2.6 billion.²⁸ The Administration believes that the mission will actually cost less than this, and NASA plans to provide a revised estimate of the mission’s cost this summer. NASA’s FY14 budget request also proposes three new initiatives totaling \$105 million, but NASA has not identified a budget profile for this mission beyond FY 2014.

²⁴NASA’s Strategic Direction and the Need for a National Consensus http://www.nap.edu/catalog.php?record_id=18248

²⁵ *Ibid.* 15

²⁶ *Ibid.* 17

²⁷ *Ibid.* 24

²⁸ Brophy, J., Friedman, L., & Culick, F. (2012). Asteroid Retrieval Mission Feasibility Study. *Keck Institute for Space Studies*, . Retrieved , from [http://www.lpi.usra.edu/sbag/documents/Asteroid percent20Return percent20Feasibility percent2020120530.pdf](http://www.lpi.usra.edu/sbag/documents/Asteroid%20Return%20Feasibility%2020120530.pdf)

Appendix- Reports on Space Exploration

1986 - The National Commission on Space (Paine Commission Report)

http://www.nasa.gov/pdf/383341main_60%20-%2020090814.5.The%20Report%20of%20the%20National%20Commission%20on%20Space.pdf

1987 - NASA Leadership and America's Future in Space: A Report to the Administrator (Ride Report)

<http://history.nasa.gov/riderep/main.PDF>

1990 – Advisory Committee on the Future of the U.S. Space Program (Augustine Commission Report)

<http://www.hq.nasa.gov/office/pao/History/augustine/racfup1.htm>

1991 – The Synthesis Group (The Stafford Report)

http://history.nasa.gov/staffordrep/main_toc.PDF

1991 - Office of Technology Assessment: Exploring the Moon and Mars

<http://history.nasa.gov/32992.pdf>

1993 – The National Space Council Report on the U.S. Space Program

<http://history.nasa.gov/33082.pt1.pdf>

2004 – President's Commission on Implementation of United States Space Exploration Policy (Aldridge Commission Report)

http://history.nasa.gov/aldridge_commission_report_june2004.pdf

2009 – Review of U.S. Human Space Flight Plans Committee (Augustine Commission Report)

http://www.nasa.gov/pdf/396093main_HSF_Cmte_FinalReport.pdf