NASA Advisory Council Recommendation

Mismatch Between NASA's Aspirations for Human Space Flight and Its Budget
2014-02-01 (Council-01)

Recommendation:
The mismatch between NASA's aspirations for human spaceflight and its budget for human spaceflight is the most serious problem facing the Agency. NASA should carefully consider what steps would have to be taken in the years ahead in order to meet the national goal of sending humans to Mars in the 2030s with a realistic budget. The Agency should be prepared to articulate these steps publicly.

Using the best available information for Humans to Mars selected from the past 40+ years of studies, NASA should identify the "minimum path" of only those technologies and capabilities absolutely required, and perform internal and independent cost estimates of this minimum path. The result should be compared to a notional 25-year budget that only grows with inflation. The resultant shortfall should be used to address what combination of budget increase, added partnerships, and/or adjustments to NASA portfolio scope would be necessary to attain the goal.

Addressing this important issue will be an ongoing process. We request that the Agency brief us regarding the implementation of this recommendation at our next meeting, and at subsequent ones.

Major Reasons for Proposing the Recommendation:
The Council agrees with the recent National Research Council (NRC) report on pathways for human exploration[1] that sending humans to Mars is an appropriate "horizon goal" for NASA. We also agree with the report's conclusion that a budget that does not grow above inflation will never allow that horizon goal to be achieved. The only ways to address this mismatch are to: (1) increase the NASA budget over projections; (2) adjust NASA's portfolio of activities; (3) offset costs with new efficiencies and/or contributions by outside partners; or (4) adopt a different horizon goal for the Agency.

Consequences of No Action on the Proposed Recommendation:
If this fundamental mismatch is not addressed in a serious way, the Agency runs the risk of squandering precious national resources on a laudable but unachievable goal.

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[1]*Pathways to Exploration – Rationales and Approaches for a U.S. Program of Human Space Exploration, National Research Council, 2014.*

NASA Response:
NASA partially concurs. NASA agrees we should carefully consider what steps would have to be taken in the years ahead in order to meet the national goal of sending humans to the Mars vicinity in the 2030s with a realistic budget. Further, we agree the Agency should be prepared to articulate these steps publicly.

NASA recognizes the need to advance the capabilities required to extend human presence into the solar system and eventually to Mars within a budget that grows only modestly over present levels. International and commercial partnerships are emerging in many areas as space capabilities diffuse and grow domestically and around the world. This offers opportunities that will continue to evolve over time and that can be leveraged. These capabilities would otherwise have to be provided by NASA. This more capabilities-based approach to our exploration strategy implementation means that we will hold open more architecture decisions while these external opportunities can be assessed, negotiated, and in some cases matured and subsequently added. This, coupled with the inherent difficulty with forecasting availability dates for selected technologies, makes it challenging to lay out and cost a minimum path to Mars. But we are, in parallel, actively assessing existing design reference approaches and identifying the figures of merit and alternate approaches that will lead to affordable and sustainable exploration systems.

We have identified the key capabilities that must be matured in order to enable future exploration. These encompass the technologies identified by the NRC and align well with those identified in NASA's Technology Roadmaps. System Maturation Teams made up of experts across NASA Centers and programs comprise these teams. In each area, they are identifying what capabilities can be advanced using the International Space Station (ISS), using Asteroid Redirect Mission (ARM) and other Space Launch System (SLS)/Orion missions in the Proving Ground of cis-lunar space, and using robotic precursor missions to Mars' orbit, moons, and surface.

Under the framework of the Evolvable Mars Campaign we introduced to the NASA Advisory Council (NAC) in June 2014, NASA is studying a split mission Mars approach that utilizes both chemical and advanced solar electric propulsion to provide a sustainable path with technologies and capabilities absolutely required for crewed missions to the Mars vicinity and Mars surface. This links to and informs studies of optimal pre-positioning of assets in cis-lunar space and Mars orbit, as well as optimal Mars surface lander sizes and other capability needs to guide technology investments. We will brief the early results of this work to the NAC in January 2015. But much additional work needs to be done over time as stated above in order to show that we have an architecture that can be accomplished both technically and programmatically, including within reasonable assumptions of future budget availability.

The series of human exploration missions NASA is planning in the Proving Ground follow this resilient and evolving approach for human exploration of the solar system. NASA is defining mission objectives of Exploration Mission-1 (EM-1) and Exploration Mission-2 (EM-2) to demonstrate the utility of lunar orbits to enable energy-efficient transfers of large masses to Mars, to conduct cis-lunar space operations we will have to master to exploit them, and to test technologies and reduce risk for the next missions. We are also using the System Maturation Team (SMT) and Evolvable Mars Campaign results to identify the set of objectives that should be accomplished in the Proving Ground over the first 5-10 years of EM flights, including the crewed mission to the asteroid redirected there by ARM.

NASA's reference plan is for this crewed mission to encompass 26-28 days, including 5 days in the stable lunar distant retrograde orbit for Orion rendezvous and docking with the ARM robotic spacecraft and attached asteroid mass, and implementing the astronauts' Extra-Vehicular Activity (EVA). There are many aspects of this crewed mission in the mid-2020's that will build capabilities and reduce risk for Mars missions such as: Moving large objects through interplanetary space using solar electric propulsion (SEP); integrated crewed/robotic vehicle stack operations in deep space orbits, e.g., integrated attitude control, solar alignment and during multi-hour EVAs; lean implementation of SEP vehicle builds using clean interfaces, streamlined processes, and common Autonomous Rendezvous and Docking (AR&D) systems; and broad scope robotic/crewed integration, including crewed system hardware deliveries to and integration and test with robotic spacecraft, and joint robotic spacecraft and crewed mission operations.

In parallel with human exploration missions in the Proving Ground, NASA is continuing its strategy of using robotic missions to advance technology and close strategic gaps in knowledge about the Martian environment that will be critical for designing future human exploration systems. The Curiosity rover continues to monitor the radiation and weather environment on the surface of Mars, and in late July 2014, NASA announced that one of the seven instruments selected for the Mars 2020 rover mission would be an exploration technology investigation that would produce oxygen from the plentiful carbon dioxide in the Martian atmosphere. If demonstrated successfully and done on a larger scale in the future, such a system could make oxygen for rocket fuel or for astronauts to breathe. Another selected instrument on Mars 2020 will provide measurements of temperature, wind speed and direction, pressure, relative humidity and dust size and shape. Understanding the Martian weather and dust characteristics will be valuable data for planning human Mars missions. In addition, Mars 2020 will include sensors on the heatshield and aeroshell to collect data during entry, descent and landing, as was done on the Mars Science Laboratory mission. The data collected will help mission planners design future landing systems human exploration. Improved navigation technologies are also being considered for the proposed Mars 2020 rover that could improve the ability of future missions related to human exploration – which likely would involve multiple payloads – to land close together.

As NASA extends human presence into the solar system and eventually to Mars in the years ahead, additional work is being defined and mission options are being developed. Mission options under study include further use of the advanced solar electric propulsion bus used for ARM; addition of a deep space habitat; additional return missions to the asteroid for expanded science and/or resource utilization; support for commercial and/or international missions in the lunar vicinity; and/or new missions to Mars vicinity that accomplish science, technology, and human exploration objectives. The past 6-12 months of work has identified options and phasing of capabilities that we had not predicted earlier, and we expect our ongoing studies to do more of the same. Over the next months and years, we will continue to define and evolve the set of missions and capability developments that accomplish the most forward progress and advance key capabilities taking close account of expected resources. In so doing, we will follow the strategic principles for exploration we discussed with the NAC in June 2014. We look forward to working with the NAC in its subsequent meetings, and discussing the findings of our architecture studies as they emerge.