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The Affording Mars Workshop: Background and Recommendations



*Participants in the December, 2013 Affording Mars Workshop at
George Washington University*

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“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.”
-- President Barack Obama, April 15, 2010

A workshop on affordable initial human missions to Mars was held at George Washington University in early December, 2013 and sponsored jointly by Explore Mars, Inc. and the American Astronautical Society. About sixty professionals from twenty organizations participated over three days and produced several consensus findings and recommendations, which may be found in full at <http://www.exploremars.org/> .

Here we summarize the background and motivation of the workshop and discuss some of the more significant workshop findings.

Background

A human mission to Mars is the stated “ultimate” goal for NASA and is widely believed by the public to be the most compelling destination for America’s space program (<http://www.exploremars.org/wp-content/uploads/2013/03/Mars-Generation-Survey-full-report-March-7-2013.pdf>). However, widely cited enormous costs – perhaps as much as a *trillion dollars* for a many-decade campaign – seem to be an impossible hurdle, although political and budget instability over many years may be equally challenging.

More recently, a handful of increasingly detailed architectures for initial Mars missions have been developed by commercial companies that have estimated costs *much* less than widely believed and roughly comparable with previous major human space flight programs: the Apollo Program, the International Space Station, and the space shuttle. Several of these studies are listed in the bibliography to the workshop report. As a consequence of these new scenarios, beginning in spring, 2013 a multi-institutional planning team began developing the content and invitee list for a winter workshop that would critically assess concepts, initiatives, technology priorities, and programmatic options to reduce significantly the costs of human exploration of Mars. The output of the workshop – findings and recommendations – would be presented in a number of forums and discussed with national leaders in human space flight. It would also be made available to potential international partners.

This workshop was planned from the start to be the first in a series. Subsequent meetings, conferences, and symposia will concentrate on topics not able to be covered in December. In addition, to make progress in short meeting, a handful of ground rules were adopted by the planning team and agreed to by the participants. Perhaps the two most notable such ground rules were (1) the Space Launch System (SLS) and Orion would be available during the time frame considered by the participants and (2) the International Space Station (ISS) would remain the early linchpin in preparing for Mars exploration over the coming decade.

We note, for example, that the workshop did not discuss much the motivations for human missions to Mars nor the goals for such missions. Motivations and goals for Mars exploration have been major topics in probably hundreds of international conferences over many decades. The organizers felt that a three-day workshop that had much else to consider could add nothing new. In any case, human exploration of Mars is a formal goal of NASA and widely popular among space exploration professionals; thus, the emphasis of the workshop would be on a topic almost never a priority in previous meetings.

The workshop organizers sought representation from a broad and representative sample of experienced American aerospace professionals

in the government, industry, and academia. International partners will be an essential component of all future human exploration and the planning team benefitted from international colleagues. The list of workshop participants is included the final report referenced above.

The workshop was organized around three topical breakout sessions:

1. The ISS and the path to Mars: The critical coming decade
2. Affordability and sustainability: what does it mean and what are its implications within guidelines established at the start of the workshop?
3. Notional sequence(s) of cost-achievable missions for the 2020s to 2030s, including capability objectives at each stage and opportunities for coordinated robotic partnerships

A summary of the workshop deliverables was presented at the February 19 Future In-Space Operations (FISO) telecon colloquium (<http://spirit.as.utexas.edu/~fiso/telecon.htm>).

In this paper we discuss in greater depth some of the consensus findings and recommendations produced by the workshop.

Workshop Output: [Principles of Agreement](#)

Five overarching principles were reached by consensus agreement:

- Mars should be the overarching goal of human space flight over the next two to three decades.

Agreement at the workshop on the first principle leads almost directly to four others:

- Identifying and solving [key technical gaps](#) over [the next several years](#) will be important in [making the human exploration of Mars feasible by the 2030s](#). Between now and 2030, human exploration of deep space must be prioritized in a manner that advances the objective of human exploration of Mars starting in the 2030s.
- Taking advantage of ISS, including international partnerships, is essential for human missions beyond LEO and, especially to Mars.
- Continuation of robotic precursor missions to Mars throughout the 2020s is essential. The robotic Mars exploration science [strategies of NASA and ESA](#) should be [coordinated](#) with humans-to-Mars efforts [while preserving their primary science objectives](#).
- [International and industrial partnerships, efficiency, consistency of purpose, and policy/budget stability are the required elements to allow a two decade-long humans-to-Mars \(H2M\) effort to succeed.](#)

The right combination of [these elements will make the H2M campaign affordable.](#)

There was much discussion at the workshop on dissipation of effort on developing capabilities not unambiguously directed toward NASA's "ultimate" goal of human exploration of Mars. In the current budget and economic environment, it is paramount that the space agencies and industrial partners concentrate their efforts on enabling the capabilities – and *only* those capabilities – necessary to achieve human exploration beyond low Earth orbit. This includes robust use of the ISS, especially given its recently announced additional four years of operational life. Moreover, time is of the essence: although it is two decades before the likely first opportunity for NASA to send humans on a round-trip mission to Mars, priority capabilities must be identified and management decisions implemented within the *next few years* if that ambitious goal is to be realized.

Although this first workshop had insufficient time and resources to consider the costs for the handful of promising scenarios presented there, it was the overwhelming consensus that initial human missions could be made far less costly than widely believed. It the responsibility of government agencies and private industry jointly to make the decisions to make this possible. [Note: It was a constant theme of the workshop that multiple stakeholders – NASA, academia, international partners, and aerospace companies of all sizes – must coordinate their efforts toward this common goal.]

Workshop Output: Findings and Recommendations

The workshop participants produced several findings and recommendations that have been presented over the past two months to senior industry and government leaders.

Highlights¹ taken from the final workshop report include (not in priority order):

- *Continuity and stability of programs and budgets:* Budgetary and policy consistency are essential. As such, the space communities need to design programs/missions that lend themselves to budgetary stability and take an incremental approach to constructing a program. Budgetary increases for inflation must also be included [as a minimum](#), so that NASA and our international

¹ *Verbatim*, although some elements have been combined for succinctness.

- partners' buying power can be maintained for the duration of this long-term program.
- *Coordinated human space exploration and related robotic activities:* These must be prioritized and conducted under the requirement that a human landing on Mars is the overarching goal [for human space flight](#). [Deviation from this will lead to delays from which it will be difficult to recover.](#)
 - *Scenarios and Cost Analysis:* Detailed scenario assessment and cost analysis is a priority effort that will require dedicated resources and sufficient time. This activity should begin soon, involve a broad community of stakeholders, and take advantage of the Global Exploration Roadmap (GER) and associated work.
 - *Level 0 and 1 Requirements:* Development and vetting of a set of highest-level requirements for human missions to Mars must be undertaken now to guide investments and designs for the coming decade.
 - *Ambitious dates for compelling near-term milestones:* These will enable efficient use of resources and expedited management, [while protecting](#) sufficient flexibility to adjust for developments of capabilities, new discoveries, and changing political environments. Notional example milestones over the coming decade include:
 - Successful demonstration of SLS and Orion
 - A Mars “free-return” mission using SLS and Orion
 - Sustained robotic science-driven exploration coordinated with human space flight goals
 - Regular progress on relevant technology capabilities developed on ISS
 - Deployment of a transitional deep-space facility in the early 2020s
 - *ISS and a “Bridge” Facility to Follow It in the 2020s:* The ISS Program should define objectives and designs for such a facility, including the options for using hardware supplied by international partners. This includes evaluating objectives that must be satisfied by the facility and the most cost-effective way to achieve them.
 - *ISS and Commercial Crew/Cargo:* Continuing improvement is welcome in strategies to communicate the role of ISS to enable commercial crew/cargo development.
 - *Improve ISS as Analog:* Reviewing current ISS logistics and processes to determine those areas that could be modified to more closely mimic initial Mars missions is very desirable. This would include an analysis that identifies which tasks are better demonstrated on ISS versus a hypothetical follow-on facility. The ISS program can also work with the technology communities to assess how ISS can best be used to support the development and demonstration of relevant exploration capabilities.
 - *Incremental Approach:* An incremental approach will be required to achieve human travel to Mars within [constrained](#) budgets. The

- incremental approach allows for modest elements of the overall plan to be assessed, carried out, and budgeted. These elements can also be offered for bid to private or international partners.
- *Avoid Single-Use Hardware:* Architectural elements, including point designs that support multiple customers and multiple goals are highly desirable because it spreads fixed cost bases and avoids repeated non-recurring engineering costs.
 - *Space agency budgets should at least keep pace with a realistic measure of inflation: [Currently NASA's budget is inadequate to support its programs. Current flat budgets are not realistic and result in reduced buying power over time. Modest increases will be necessary to achieve adequate support of this and other NASA priorities.](#)*
 - *Alternate Management Models:* Alternate [acquisition and development methods](#) should be considered to create efficiency, such as a hybrid contracting approach, and [employing](#) other innovative management approaches. [These could include](#) streamlined government oversight and Skunk Works/Phantom Works-like structures.
 - *Essential robotic and human precursor missions:* These will be necessary [and](#) must clearly advance capabilities required for crewed missions to the surface of Mars.
 - *Clear returns for stakeholders:* This can be achieved by [developing](#) missions and capabilities in concert with national and international partners. Development of partnerships among industry, academia, other government agencies, and multiple agency directorates will allow leveraging of resources and talent.
 - *Consistent and continuous communication is essential, including*
 - Assuring that stakeholders (political leaders, policy makers) are fully informed of progress, program goals, and the criticality of stable budgets.
 - Developing a coalition of advocates from industry, government, academia, human space flight, and science communities who share a common interest.
 - Clearly and regularly communicating to the public the achievements and benefits of the program

Closing Observation

The workshop closed its report with

[Affordability and sustainability will require dedicated effort. Careful coordination among stakeholders, NASA, industry/commercial, and potential international partners will be required. The human space flight stakeholders must initiate new and sustainable programs that will clearly advance the goal of](#)

landing crews on Mars by the mid 2030s. A logical, affordable architecture with a campaign of mission ‘stepping stones’ and elements must be developed. From the start, such an architecture must incorporate management efficiencies, and flexibility based on lessons learned from ISS, commercial programs, and other past NASA programs, as well as from DOD and industry. Above all, political and budgetary stability is essential over a two-decade time span. These expectations and the ability to build on our heritage and past investments may not last long and must be exploited before the opportunity slips away.

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