

Issues and Challenges in Sustainability

The Third Community Workshop on Affording and Sustaining
Human Mars Exploration (AM III)

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Mark Craig .. Mary Lynne Dittmar .. Dan Dumbacher .. Ann Zulkosky

Sustainability

- Sustainable => able to be continued indefinitely
 - ✓ An enterprise that is sustainable IS by definition affordable
 - ✓ An enterprise that is affordable IS NOT by definition sustainable
- Specifically what will enable human Mars missions to continue after the first several, unlike Apollo? And what will defeat the “been there done that” threat?
- Bases for sustainability
 - ✓ 2015 NASA’s Journey to Mars Pioneering Principles - “... the basis for a sustainable, affordable space program ...”
 - ✓ 2014 NRC Pathways to Exploration Report - “ ... recommendations to enable a sustainable U.S. human spaceflight program”
 - ✓ 2010 the bi-partisan NASA Authorization Act human space flight and exploration Long Term Goal “.. to expand permanent human presence beyond low-Earth orbit ...” and achieve Key Objectives

Common Bases for Sustainability

- NASA “Pioneering Principles” and the NRC Report -

NASA “Pioneering Principles”	NRC Report Recommendations
Journey to <u>Mars</u>	Mars is the "horizon goal"
Implementable in the near-term with the buying power of current <u>budgets</u> and in the longer term with budgets commensurate with economic growth	The pathway is affordable without incurring unacceptable development risk
Exploration enables <u>science</u> ...	The horizon and intermediate destinations have profound scientific ... benefits that justify public investment
Application of high TRL <u>technologies</u> for near term missions, while focusing sustained investments on technologies and capabilities to address challenges of future missions	Engage in planning that includes Mission requirements and a systems architecture targeting funded high-priority technology development
Near-term mission opportunities with a defined <u>cadence</u> of compelling and integrated human and robotic missions providing for an incremental <u>buildup of capabilities</u> for more complex missions over time	<ul style="list-style-type: none"> + Define steps on the pathway that ... maintain progress on achieving the pathway's long-term goal + The sequence of missions and destinations permits stakeholders, including taxpayers, to see progress + The pathway supports an operational tempo that ensures retention of critical technical capability, proficiency of operators, and effective utilization of infrastructure
Opportunities for U.S. <u>commercial</u> business to further enhance the experience and business base	Vigorously pursue opportunities for .. commercial collaboration
<u>Resilient architecture</u> featuring multi-use, evolvable space infrastructure, minimizing unique major developments, with each mission leaving something behind to support subsequent missions	<ul style="list-style-type: none"> + The pathway is characterized by logical feedforward of technical capabilities + The pathway minimizes the use of dead-end mission elements that do not contribute to later destinations
Substantial new <u>international</u> and <u>commercial</u> participation, leveraging current International Space Station partnerships and building new cooperative ventures for exploration	<ul style="list-style-type: none"> + Vigorously pursue opportunities for international and commercial collaboration + Engage international space agencies early in design and development of the pathway + Seek continuously to engage new partners

Unique Bases for Sustainability

- NASA “Pioneering Principles” and the NRC Report -

Bases Unique to NASA “Pioneering Principles”

- ✓ ... science enables exploration, leveraging robotic expertise for human exploration of the solar system

Bases Unique to NRC Report Recommendations

- ✓ Redirect, consolidate, and eliminate human spaceflight asset base as needed
- ✓ Pathway addresses the enduring questions of how far from Earth can humans go and what can humans discover and achieve when they get there?
- ✓ Define steps on the pathway that foster sustainability ...
- ✓ Create a risk mitigation plan
- ✓ The horizon and intermediate destinations have profound ... cultural, economic, inspirational, or geopolitical benefits that justify public investment.

Sustainability and AMIII

- A Level 0 requirement for Mars human exploration architectures is identification of the sustaining sources of funding and how the architecture will return value commensurate with its cost to stakeholders
- Workshop Deliverables
 - ✓ Observations and commentary on the affordability and sustainability of Mars architectures and strategies presented at the workshop
 - ✓ Outreach and engagement strategy to professionals, especially with respect to other scientists, engineers, and architects of human space flight scenarios
 - ✓ A professional engagement strategy to the general public and stakeholders

Observations

- “Means” and “ends” ... Mars as the “end” - when reached - is the end. Mars AND Bust!
- So, Mars is a “means” ... but to what sustainable “end” ?
- The long term goal of NASA human space flight and exploration is “.. *to expand permanent human presence beyond low-Earth orbit ...*” (bi-partisan NASA Authorization Act of 2010). A goal ratified by the 2015 Pioneering Space National Summit
- The ultimate basis of sustainability is value .. benefit .. to stakeholders:
 - ✓ Value built in and experienced by stakeholders, not simply asserted by NASA
 - ✓ Value commensurate with its cost
 - ✓ Stakeholders with sufficient collective leverage to influence outcomes
- Significant international and commercial stakeholder “skin in the game” is critical to sustainability .. in time and over time. NASA exploration can neither get too far ahead of nor too far behind international and commercial stakeholders
- Engagement ... engagement professionals shouldn’t design spacecraft; engineers and scientists shouldn’t design engagement
 - ✓ Engagement requires resource and time ... a campaign
 - ✓ Engagement creates narrative to connect “dots” and arouse excitement
 - At the highest enterprise level - the book ... the larger story
 - And at compelling lower levels - a chapter and verse

Back-Up

NASA's Pioneering Principles “Basis for a Sustainable, Affordable Space Program”

1. Implementable in the near term with the **buying power of current budgets** and in the longer term with **budgets commensurate with economic growth**
2. Exploration enables **science** and science enables exploration, leveraging scientific expertise for human exploration of the solar system
3. Application of **high Technology Readiness Level (TRL)** technologies for near-term missions, while focusing **sustained investments** on technologies and capabilities to address challenges of future missions
4. Near-term mission opportunities with a defined **cadence** of compelling and integrated human and robotic missions, providing for an **incremental buildup** of capabilities for more complex missions over time
5. Opportunities for **U.S. commercial business** to further enhance the experience and business base
6. **Resilient architecture** featuring multi-use, evolvable space infrastructure, minimizing unique major developments, with each mission leaving something behind to support subsequent missions
7. Substantial **new international and commercial partnerships**, leveraging current International Space Station partnerships and building new cooperative ventures for exploration

NASA Authorization Act of 2010

- Sec. 202: Human Space Flight and Exploration Goals & Objectives -

Long Term Goal – To expand permanent human presence beyond low-Earth orbit and to do so, where practical, in a manner involving international partners.

Key Objectives - The key objectives of the U.S. for human expansion into space shall be to:

- Sustain the capability for long-duration presence in low-Earth orbit:
 - ✓ Initially through continuation of the ISS and full utilization of the U.S. segment of the ISS as a National Laboratory,
 - ✓ Through assisting and enabling an expanded commercial presence in, and access to, low-Earth orbit, as elements of a low-Earth orbit infrastructure;
- Determine if humans can live in an extended manner in space with decreasing reliance on Earth, starting with utilization of low-Earth orbit infrastructure
- Identify potential roles that space resources such as energy and materials may play to meet national and global needs and challenges, such as potential cataclysmic threats
- Explore the viability of and lay the foundation for sustainable economic activities in space;
- Maximize the role that human exploration of space can play in:
 - ✓ Advancing overall knowledge of the universe
 - ✓ Supporting U.S. national and economic security and the U.S. global competitive posture
 - ✓ Inspiring young people in their educational pursuits
- Build upon the cooperative and mutually beneficial framework established by the ISS partnership agreements and experience in developing and undertaking programs and meeting objectives designed to realize the goal of human space flight set forth above

NASA Authorization Act of 2010

- *Sec. 204: Independent Study on Human Exploration of Space* -

In General - In fiscal year 2012 the Administrator shall contract with the National Academies for a review of the goals, core capabilities, and direction of human space flight, using the goals set forth in:

- National Aeronautics and Space Act of 1958
- NASA Authorization Act of 2005
- NASA Authorization Act of 2008
- Goals set forth in this Act
- Goals set forth in any existing statement of space policy issued by the President.

Elements - The review shall include:

- A broad spectrum of participation with representatives of a range of disciplines, backgrounds, and generations, including civil, commercial, international, scientific, and national security interests
- Input from NASA's international partner discussions and NASA's Human Exploration Framework Team
- An examination of the relationship of national goals to foundational capabilities, robotic activities, technologies, and missions authorized by this Act
- A review and prioritization of scientific, engineering, economic, and social science questions to be addressed by human space exploration to improve the overall human condition
- Findings and recommendations for fiscal years 2014 through 2023

Statement of Task: "... review the long-term goals, core capabilities, and direction of the U.S. human spaceflight program and make recommendations to enable a sustainable U.S. human spaceflight program."

2015 Pioneering Space National Summit - Statement of the Participants -

February 20, 2015 - This week a diverse group of over 100 space leaders from academia, government and industry came together at the Pioneering Space National Summit in Washington D.C. and moved beyond the endless debates about destinations and launch vehicles and achieved consensus. Together they were able to forge the following statement:

The long term goal of the human spaceflight and exploration program of the United States is to expand permanent human presence beyond low-Earth orbit in a way that will enable human settlement and a thriving space economy.

This will be best achieved through public - private partnerships and international collaboration.

The participants agreed that this statement is consistent with and builds upon the 2010 NASA Authorization Act (Public Law 111-267), and the journey it helps the nation begin will serve many national interests and benefit the American people.

AMIII Workshop Outcomes and Deliverables

- Observations and commentary on the affordability and sustainability of Mars architectures and strategies presented at the workshop, especially elements of Mars architectures that are robust against cancellation or delay.
- Priority science objectives enabled by human presence in the vicinity of Mars and elements of Mars architectures particularly useful to scientific exploration.
- Findings and recommendations on viable common features and capabilities of different architectures, priority near-term actions and investments for the space agencies and industrial partners, future design and architecture studies, international participation, etc.
- Outreach and engagement strategy to professionals, especially with respect to other scientists, engineers, and architects of human space flight scenarios: follow-on workshops, conference presentations, briefings to NASA and other human space flight leaders
- A professional engagement strategy to the general public and stakeholders

A Level 0 requirement for Mars human exploration architectures is identification of the sustaining sources of funding and how the architecture will return value to stakeholders.