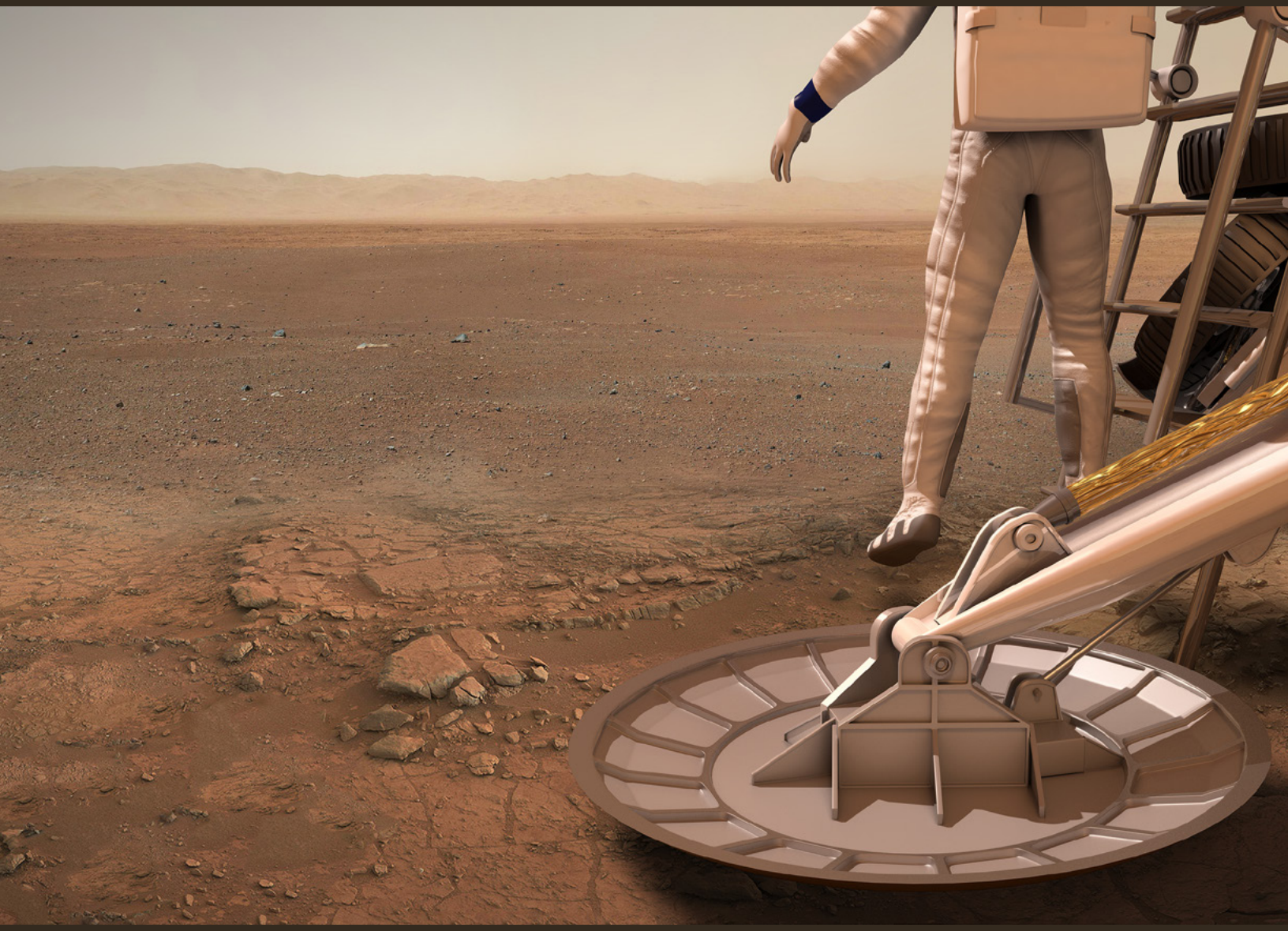
THE HUMANS TO MARS REPORT 2015



AN **EXPLORE MARS** PUBLICATION

Introducing The **Humans** To **Mars Report**

Significant strides towards the goal of sending humans to Mars have been made over the last few years, not only through advancements in planning and capabilities, but also in the political realm. However, despite this progress, there is a common misperception that there has been little or no motion forward in humanity's efforts and ability to actually achieve this goal.

It is too often the case that policymakers, the public, and even space stakeholders are confused about what technologies should be emphasized, whether missions are feasible and whether they will be affordable, and how broad the support base is for humans to Mars.

To address this issue, Explore Mars, Inc. has produced the first annual Humans to Mars Report (H2MR). The H2MR provides updates on challenges, plus progress in areas such as mission architecture design and development, scientific discoveries, policy, public perception, international cooperation and competition, and new private capabilities. In addition to the printed report, H2MR will maintain a website that archives support materials used to produce the printed report. Once launched in August 2015, the site will serve as a valuable resource for interested parties and members of the press.

Maintaining a long-term sustainable program is challenging enough, and so policy makers and members of the space community must be made more fully aware of the current challenges and recent progress, in order for them to make the most informed decisions on budgets and long-term plans and strategy for getting humans to Mars. Bringing this information to the forefront of the discussions is one of the great benefits that H2MR is intended to provide.

There is, of course, justification for skepticism and frustration over the pace of progress and decision making. Progress could have been faster, budgets could have been more generous, and political will could have been stronger and steadier in the past few decades. We realize that it is impossible to predict every budgetary and technical challenge that will arise as we prepare to land humans on Mars. We can expect new players to emerge and political, economic, and international variables to impact the trajectory of the pathway to Mars; still, it will be far easier to chart our path to Mars if there is an independent annual analysis of progress, challenges, and developments. The Humans to Mars Report will serve as this analytical tool.

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Explore Mars was created to advance the goal of sending humans to Mars within the next two decades. To further that goal, Explore Mars conducts programs and technical challenges to stimulate the development and/or improvement of technologies that will make human Mars missions more efficient and feasible. In addition, to embed the idea of Mars as a habitable planet, Explore Mars challenges educators to use Mars in the classroom as a tool to teach standard STEM curricula.

Explore Mars, Inc. is a 501(c)(3) non-profit corporation organized in the Commonwealth of Massachusetts. Donations to Explore Mars are tax-deductible. You can Contact Us using our website or at the email address info@ExploreMars.org

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MARS SCIENCE
Paving the Way

The scientific trajectory for Mars exploration has been in continuous development and refinement since NASA's current robotic Mars Exploration Program (MEP) was established in 2000. This program has evolved to include the ongoing surface-based scientific exploration by the Mars Exploration Rover, Opportunity and the Mars Science Laboratory Curiosity rover, the first-ever mobile analytical laboratory on another planet. It includes the state-of-the-art investigation of the upper atmosphere of Mars by the Mars Atmosphere and Volatile EvolutioN (MAVEN), the Mars Reconnaissance Orbiter (MRO) as well as plans for in situ molecular analysis via the Mars Organic Molecule Analyzer (MOMA) on the European Space Agency's ExoMars'18 drilling rover. A new era of science-guided exploration will ensue with the 2020 caching rover, likely to be followed by intensified orbital reconnaissance and partnerships with human exploration and other institutions to achieve robotic sample return. This scientific exploration of Mars produced multiple "revolutions" and a realization that the planet we thought we were unveiling during the first era of exploration (circa 1971 to around 1996) is far more intriguing than we first suspected. New possibilities include recognition of ancient habitable environments, preservation of organic molecules, and evidence of dramatic climate upheavals. As we look ahead, the prospects of learning about the fate of organic molecules on Mars, how active the planetary interior may be, and whether preservation of bio-signatures is possible or likely are all very real, with missions either in place or planned to address these keystone issues about the Red Planet.

We have achieved scientific breakthroughs over the past decade that strongly suggest that Mars was once a habitable world with appropriate chemistry, sources of energy, liquid water, and related environmental factors that would have been conducive to life as we presently understand it here on Earth. Finding signs of preserved bio-signatures that demonstrate that this ancient habitable Mars was indeed inhabited, even if only by episodic microbial life, would be humanity's first evidence of extraterrestrial life. Today, the collective efforts of NASA, international space-faring nations, industry, and academia are poised to produce discoveries that could change the longer-term trajectory of exploration of the planet, perhaps leading to an accelerated pathway for human-based surface exploration by the 2030s. Major breakthroughs in technical and scientific instrument capabilities are within reach, and moving from our present era of high-latency telepresence to one with both low-latency telepresence (humans near Mars) or zero-latency telepresence (humans on Mars) is an essential element in global exploration strategies.


CREDIT:NASA JPL

The Past Five Years

Over the past several years, the all-robotic scientific exploration of Mars has moved from the era of interleaved, intensive reconnaissance via orbital remote sensing and surface missions to a new era of surface-based analytical measurements, as well as the first in situ analysis of the upper atmosphere. These breakthroughs in capability have come as a consequence of a systematic, integrated program of exploration led by NASA but also through engagement of partners such as the European Space Agency, the Canadian Space Agency, ISRO, Italy, Russia, Spain, Finland, and many others. Some of the most notable discoveries include:

- Mars was once a habitable environment
- Organic molecules are present on the surface of Mars
- The surface of Mars may be active today, with flowing liquid brines and geysers of gas emissions.

Exploration systems (delivery, mobility and measurements) have experienced major advances as our understanding of the martian environment has improved. This ongoing experience will enable future systems to be more effective at a lower cost, and ultimately pave the way for effective, highly-informed human exploration embracing scientific goals.

The Next Five Years

Planning for a 2020 Mars science and exploration rover with the ability to conduct next-generation surface reconnaissance while creatively caching materials for eventual return to Earth is progressing under the leadership of NASA's Jet Propulsion Laboratory (JPL), with support from other centers, industry, and international partners. Programmatically building off the legacy of MER/Opportunity and MSL/Curiosity as well as the ongoing reconnaissance by MRO, a new era is set to begin with the M2020 caching rover. This new rover will integrate payloads in direct preparation for future human exploration of Mars [In-Situ Resource Utilization (ISRU), shallow high-resolution ground penetrating radar, environmental assessment], and could potentially also include the first implementation of active hazard avoidance to permit access to even more scientifically compelling linading sites.

An Integrated Approach

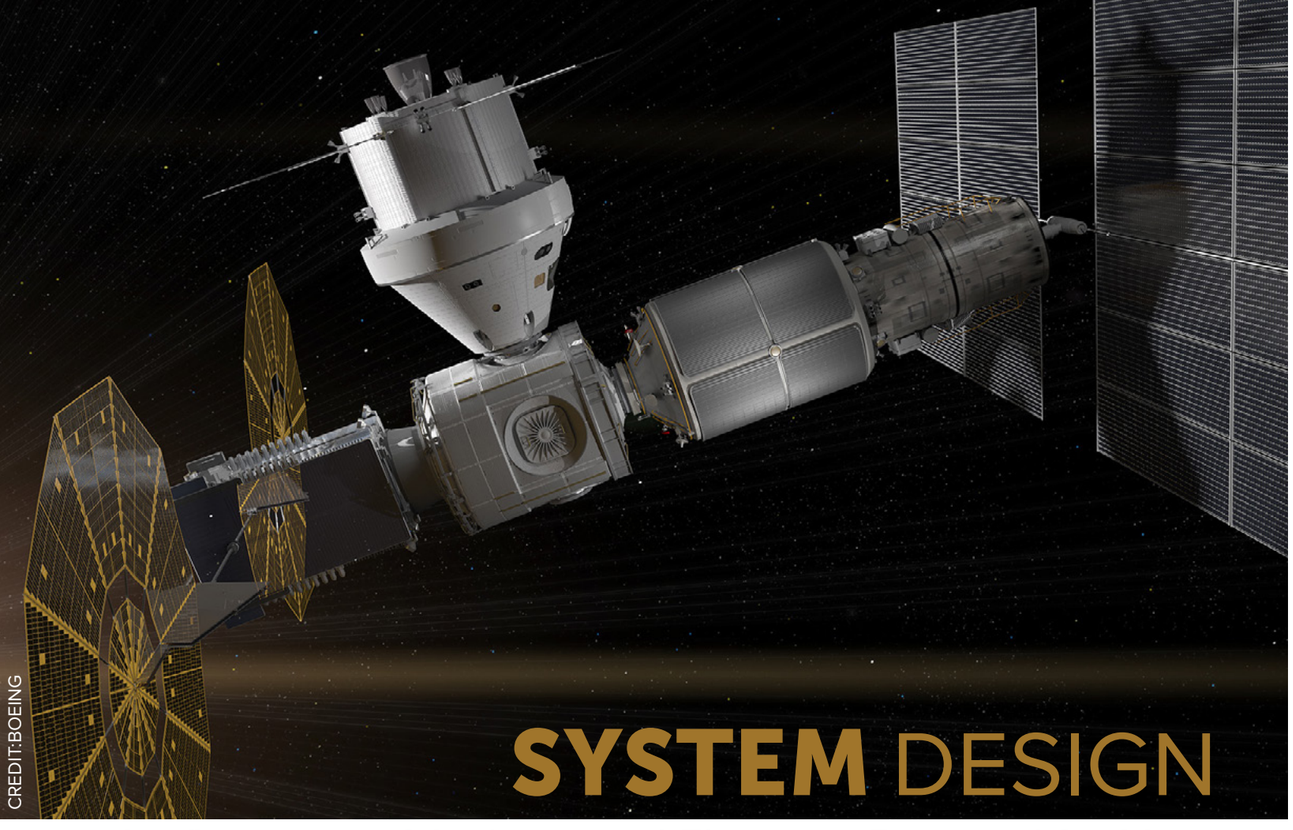
Integration of human space flight capabilities with flight-proven robotic ones is a key element of the emerging strategies so that a campaign of Mars exploration involving both human explorers and supporting robotics can be attained. It is well recognized that the affordability of such a campaign is an essential aspect of all strategic planning and that innovative partnerships will be needed to enable people to safely visit Mars and return to Earth in the next ~20 years.

The prospects for an integrated human and robotic strategy for Mars exploration for the next 20 years are crystallizing with a goal that humans will visit Mars during the 2030s. The first steps required to achieve that goal are underway on Mars today.

Recommendations

Priorities beyond 2020 include:

- Instruments to directly measure organic molecules and their ties to biological processes, if any exists.
- Systems to return cached samples to Earth for comprehensive analysis for science and planetary protection.
- A new generation of telecommunications and reconnaissance orbiters is under consideration
- Capabilities for rendezvousing with samples launched to low Mars orbit
- Potential for using solar electric propulsion to return such orbiting samples to the vicinity of the EarthMoonsystem for retrieval.



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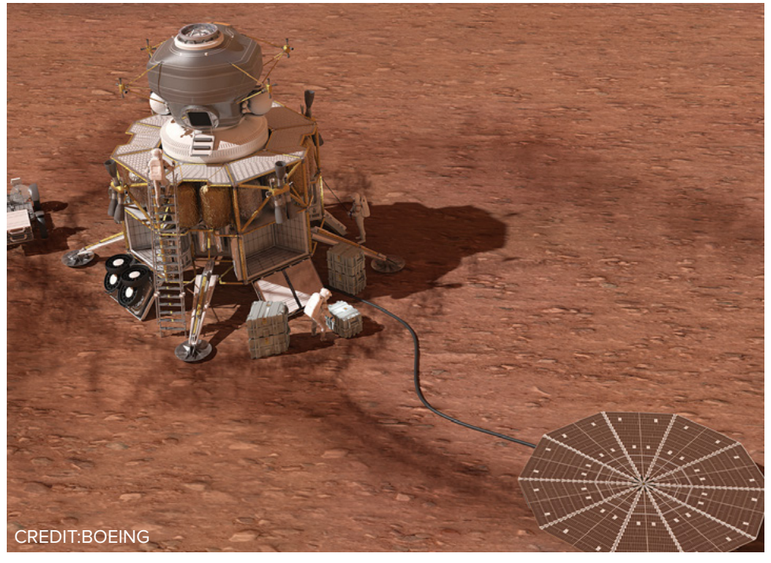
An Overview of Architectural Elements Required for Mars

NASA's most recent design reference architecture for a human mission to Mars, known as DRA 5.0, was released in 2009. This important study continues to evolve and the latest addendum was released in 2014 [www.nasa.gov/sites/default/files/files/NASA-SP-2009-566-ADD2.pdf]. NASA has also engaged with industry and international partners through the International Space Exploration Coordination Working Group (ISECG) [www.nasa.gov/exploration/about/isecg/#.VTE4TM4hqkQ] and dedicated workshops focused on affordability and sustainability of the mission [www.exploremars.org/affording-mars]. Previous mission design and architecture studies have been revisited and updated to reflect an emphasis on reducing the overall cost, as well as keeping the annual cost of the required efforts within an assumed budget.

All of these activities have set the goal as humans reaching the martian surface by the mid- to late-2030s. Since DRA 5.0, NASA has defined an approach that would determine the required elements for various architectures (monolithic vs aggregated in orbit, split crew-cargo, etc.) and then run out a budget profile for the development and operations of the required elements and missions to achieve the goal. NASA has recently been building on these studies with another round of architecture definition studies referred to as the Evolvable Mars studies. A snapshot of this activity at the current time is also found on the website. [www.nasa.gov/sites/default/files/files/2-20150112-NAC-Crusan-v6.pdf] Several industry teams have also been revisiting Mars architectures.

The Aerojet architecture was summarized at the Global Exploration (GLEX) Conference in May 2012 and also described in articles in Mars Exploration Magazine. [http://exploremars.org/MEM/MEM-July-2011.pdf] Basically the study was done in a classic "right – to –left " manner, meaning that the required elements on Mars and the desired timing of the landings served as the starting points and the architecture worked its way backwards to launch from Earth. This study identified efficient in-space transportation and splitting the cargo and crew transportation as important for a sustained Mars campaign. Cargo transport was accomplished using Solar Electric Propulsion (SEP).

Boeing has examined a similar architecture except that their crew transfer is also accomplished using SEP. The SEP transfer module is a common design between the cargo and the crew versions. The one difference is that the crew version uses a chemical "kick stage" to perform a significant fraction of the departure burn to reduce the trip time for the crew. This architecture can take advantage of operations in cis-lunar space and use the infrastructure that is deployed for proving ground missions by staging the SEP vehicles in cis-lunar space. [www.youtube.com/watch?v=vdqhGhfX62Y]



CREDIT:BOEING

Lockheed Martin has defined an approach utilizing either cis-lunar habitat or near earth asteroids that builds up more progressively difficult missions as a path to Mars. These approaches are documented in papers found on the website. One proposed use for a cis-lunar habitat is the teleoperation of robotic rover on the lunar farside.

SpaceX has announced plans to unveil a Mars architecture in the near future. Details are not available at the time of this report's publication, but will be added to the website as they become available and in future annual reports.

The Six Key Elements to a Mars Architecture


CREDIT:NASA

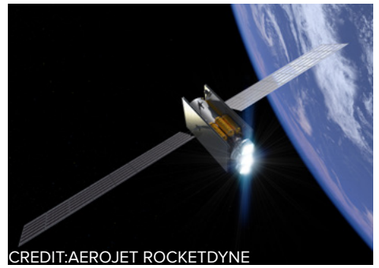
1. Orion EFT-1

The Exploration Flight Test -1 mission of the Orion multi-purpose crew module built by Lockheed Martin was an unqualified success. Launched on a Delta IV Heavy rocket, Orion was lofted 3600 miles above Earth and returned with a velocity of 20,000 miles per hour to test the performance of the heat shield and thermal protection system. The test also provided important insight into key separation events, including whether the Launch Abort System and protective fairings came off at the right times, how the parachutes assisting Orion during its descent fared and how the operations to recover Orion from the Pacific Ocean progressed. All systems performed as expected.


CREDIT:ATK

2. SLS

In the past year, hardware and major elements of the SLS rocket have begun to come together. In January 2015, a 500 sec test of the RS-25 engine with the updated flight controller was performed at NASA's Stennis Space Center. In March 2015, a full 5 segment solid rocket booster was successfully fired at Orbital ATK's Promontory, UT facility. These are the two major propulsive elements that will power SLS into space. SLS core vehicle development is underway led by Boeing at the Michoud Assembly Facility in Louisiana. The critical design review (CDR) for the core stage was completed in June 2014 and flight qualification parts are being fabricated now.


CREDIT:AEROJET ROCKETDYNE

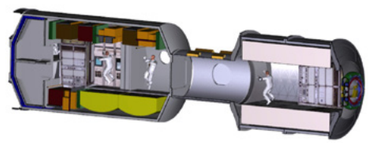
3. SEP

The technology development for the Solar Electric Propulsion technology demonstration mission (TDM) made great strides in the past year. Both contractor teams had successful ground tests of the large 25 kW solar array wings (SAWs) that are the first step toward the cargo transport vehicle. NASA continued work on higher power Hall thrusters and power processors and has demonstrated lifetimes consistent with missions such as the Asteroid Redirect Mission, which provides a representative test for a Mars cargo mission by moving a 10 MT asteroid into lunar orbit. Readiness dates for a TDM for both the arrays and the EP system are planned for 2019.

Recommendations

- Progress on Orion and SLS is critical as these programs complete development and move into their flight test phase over the next few years. Leadership focus on these programs has been excellent and should remain at its current high level.
- The next two elements needed are the SEP stage and the Deep Space Habitat. These programs should be entering preliminary design phase now to support testing in the early 2020's and they will be required for any Mars precursor scenario, whether it is an asteroid retrieval mission or a lunar test mission. Transition from the technology phase to the preliminary design phase should be a high priority for 2016. Consider subsystem testing on ISS.
- Technology development on the Lander and Mars Ascent Vehicle should continue with robust support through 2020. Subscale models could be used for validation testing and potentially in support of a robotic sample return mission in the mid 2020's.

"All of these activities have set the goal as humans reaching the martian surface by the mid- to late-2030s."


CREDIT:NASA

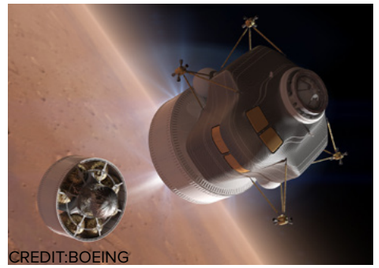
4. Deep Space Habitat

NASA has been examining concepts for a habitat that can be placed in a location in cis-lunar space and used to demonstrate the systems needed for the long duration of a Mars mission. By placing such a habitat in L2 or a distant retrograde orbit around the moon, crews can reach it using SLS and Orion and can experience the same environment (both microgravity and radiation) that they will experience in transit to Mars. Boeing and Lockheed Martin have concepts based on ISS modules. Other commercial designs are also being proposed. The Affording Mars workshops have endorsed such a "bridge" mission as the logical next step between the ISS and a human Mars mission. Additional definition of the concept is expected from NASA's Evolvable Mars studies this year.


CREDIT:NASA

5. EDL

Entry, Descent, and Landing (EDL) is a critical technical hurdle that must be overcome to enable human missions. Current technology (Mars Science Laboratory) is able to place a 1MT rover on the surface. For human missions we need to place much larger objects (habitats, ascent vehicles, etc.) on the surface. Development of better EDL techniques is required to do this. This past year NASA conducted a test of an inflatable aerodynamic deceleration device at an altitude designed to simulate martian atmospheric densities. The Low Density Supersonic Deceleration (LDSD) test, provided valuable data for the design of a large mass EDL technique. Another technique for landing larger masses on the martian surface is supersonic retro propulsion. Data on this technique was obtained from SpaceX booster flyback tests and shared through a partnership with NASA. Another LDSD test is planned for Summer 2015.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6. Mars Ascent Vehicle

The ascent vehicle for Mars will be one of the most challenging designs because of the large impact its mass and the mass of propellant required to launch from the surface to Mars orbit has on the overall mission design. The propellant mass for the ascent vehicle can be dramatically reduced through the use of ISRU (in-situ resource utilization). A significant step was announced this past year with the agreement by the Mars 2020 science team to fly an ISRU demonstration called Mars Oxygen In-Situ Resources Utilization Experiment (MOXIE). This small scale demonstrator will attempt to produce oxygen from martian resources.

Additional information and updates on these six critical elements will be posted to the H2MR website when it goes active this fall.

One result from the two Affording Mars workshops was that each of these architectures included a number of common elements. Many of these elements of the Mars exploration architecture are already in development and significant progress has occurred during the past year. They are listed above in relative order of technical maturity.

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POLICY: OPPORTUNITIES and CHALLENGES
The Path Forward

Domestic Policy

The last two years have seen substantial progress in building consensus for a human spaceflight program beyond low Earth orbit. The NASA Authorization Act of 2010, which, in Section 301(a)(1) calls for the "extension of the human presence… to other regions of space beyond low-Earth orbit", also points, in Section 301(a)(5), to the "international exploration of Mars" as the ultimate long-term objective for human exploration of space. Recently proposed authorization language, which has not yet been enacted, goes further to say that, "it is the policy of the United States that the goal…shall be to successfully conduct a crewed mission to the surface of Mars to begin human exploration of that planet."

Senator Bill Nelson (D-FL) – Sept 2014
"…our destiny is to explore and break new frontiers, and Mars is the next goal…"

With respect to actual appropriations, in the absence of sequestration constraints the Congress has supported modest increases in NASA funding above the requested levels, especially in supporting exploration-related activities. Congressional support for the Orion and SLS programs described earlier in this report has been strong, and this support has come from key members on both sides of the aisle.

Representative Donna Edwards (D-MD-4th) May 2013
"The Moon, near Earth asteroids, and Lagrangian points are among the destinations that can be considered to help prepare for eventual human exploration of Mars."

Reaching beyond the traditional Congressional support base: A common plea from professional space staffers and traditional Congressional supporters is that space advocates need to spend more time speaking to members of Congress (1) who are not reliably supportive of space exploration, (2) who are not from states that are traditionally regarded as "space states", and/or (3) members whose opinions are not yet known. Over the last few years efforts to reach these members have been expanded, and unexpected space exploration supporters have been found on Capitol Hill, but thus far the follow-through with these non-traditional supporters has been insufficient. To help better highlight and harness the support and passion of these non-traditional supporters, these outreach efforts need to be expanded.

The current administration has also shown support for missions to Mars. President Barack Obama in his 2015 State of the Union address stated, "Last month, we launched a new spacecraft as part of a re-energized space program that will send American astronauts to Mars."

Indeed, there has been administration support for human missions to Mars over numerous presidencies. George H.W. Bush, George W. Bush, and Barack Obama all established Mars as the horizon goal of the US space program. However, a consistent and sustainable (politically and fiscally) program has not been achievable in that timeframe. It has been the pattern that each new administration has either reduced the priority of or redirected the program. As a result of congressional "intervention" with the 2010 NASA Authorization Act, a degree of continuity has been established in exploration-related activities, and there has subsequently been significant progress in initiating the development of the essential transportation capabilities needed for long term exploration. It is vital that the next administration not undertake yet another major reconfiguration of the nation's established human space flight program. If there are ways to improve the program, these should be considered. However, new efforts should be based firmly on the substantial progress achieved to date."

Representative Steven Palazzo (R-MS-4th) Feb 2014
"We must ensure that future exploration endeavors lay the groundwork for an eventual human landing on Mars."

International Policy

European Space Agency Director General, Jean-Jacques Dordain, stated recently that the US should "lead the global exploration of space…" [7th AAS Wernher von Braun Symposium].

The U.S. leads the world in space exploration achievements, contributing knowledge and inspiration to people around the world. Our expertise and resources in both human and robotic space exploration position NASA to lead a sustainable international effort extending human presence in the solar system, with future Mars missions as the driving goal. As in the US, there is international consensus that Mars should be the horizon destination for human space flight over the next few decades. As an example, this is highlighted in a recent report called, Exploring Together: ESA Space Exploration Strategy. The report states, "Missions to Mars are the ultimate challenge, including the return of samples and the close cooperation between robots and humans on the surface of Mars." Several international space agencies would like to make critical path contributions to a sustainable human space exploration effort, leading to major roles in human missions to Mars. For this reason, some of our potential partners consider missions to the surface of the Moon as an important step to Mars. Regardless of the specific mission architecture that is undertaken, any international partners need to be shown that the U.S. is a reliable partner and that a consistent and sustainable pathway, which considers their interests, is available.


CREDIT:ESA

It is also clear that other nations beyond our traditional partnership base, such as China, India, and others, are interested in sending humans to Mars. As plans mature, we need to start considering our long-term relationships with these other players. Will they be competitors or partners?

Recommendations:

- A concentrated effort should be made to help Congressional members and staff better understand the historical evidence of the return on investment from space-related expenditures, the breadth and depth of the long-term value to the economy, the effect on STEM education, and to improving the human condition. Particular effort should be made to identify and engage non-traditional Congressional supporters of space exploration.
- Candidate outreach: Over the next two years, coordinated efforts must be made to educate viable candidates for President (and their staff) of the value not only of human missions to Mars, but also of maintaining a consistent and sustainable program. The next President can make a significant positive contribution to the international goal of Mars exploration by building upon the technical progress made over the past few years.
- Science and Policy Exchange: A program or partnership similar to the Science and Entertainment Exchange [http://www.scienceandentertainmentexchange.org/] should be established to help educate staffers, members, and other policy makers about key science and engineering issues.
- International collaboration for Mars is the stated policy in current U.S. law and NASA should be encouraged to continue its efforts through the International Space Exploration Coordination Group (ISECG) and other programmatic forums to work with International Partners on potential roles and contributions.

THE **HUMAN** ELEMENT

Public Perception of Mars Exploration

The public is fascinated with Mars. The 2012 landing of the Curiosity Rover generated worldwide excitement and inspired a new generation of space enthusiasts. This fascination with Mars has grown with subsequent discussions about the prospect of past or present life on Mars. But does that fascination translate into solid support for future robotic and human exploration? This section examines public perception of Mars exploration and what factors influence that perception.

NASA and Government Agencies

NASA remains a powerful and influential force with a strong public communications platform. NASA's social media and other outreach efforts have increased its audience reach and engagement significantly. NASA has 18 million and 15 million in extended audience reach on Facebook and Twitter respectively. While their popularity with the media during the Space Shuttle program was significant, the expanded use of these new mediums and platforms have led to a more engaged and interactive audience. The regular release of photographic, video, and live video assets and more creative content and storytelling has made space exploration a far more popular topic of public conversation.

However, NASA's impact is not unlimited. Despite its communications savvy and the public relations successes it has had over the past few years (such as the Curiosity landing), there are nevertheless a significant number of people who are under the impression that our space program ended when the Space Shuttle fleet was retired. This appears to be a result of the public's strong association of NASA with human space flight. The recent Orion capsule test received a significant level of press coverage and appeared to resonate with the public, but public engagement can not be sustained over the long term solely by infrequent news flashes. Major technical and scientific milestones must be effectively communicated so that the public and policy makers understand how they advance the goal of crewed missions to Mars.

New Commercial/Private Exploration Ventures

New players in space exploration have emerged in the last 10 to 15 years, and the outreach efforts of these organizations have had an impact on public perception. It is unclear whether the ambitions and successes of these ventures is differentiated from NASA's efforts by the general public and what impact, if any, they have on the public's support of government spending on space exploration programs.

SpaceX: Elon Musk and SpaceX have been quite clear that the long-term goal of the company is to help make civilization multi-planetary—including a primary focus of landing humans on Mars. SpaceX's overall efforts have always kept Mars exploration at the forefront, and are part of the reason behind its emphasis on reusable rockets, spacecraft that can land propulsively, and audacious goals that help foster more excitement in the public generally about visiting the Red Planet.

Individuals and Personalities: The outreach involvement by dynamic personalities like Elon Musk, Buzz Aldrin, Richard Branson, etc. in communicating and supporting their passion for space exploration is an influencer of public perception and interest in these projects. They generate interest and media coverage not only through their exploration efforts, but their general presence and leadership. As an example, "Get Your Ass to Mars" is the slogan and platform driven by astronaut and moonwalker Buzz Aldrin. His social media presence is growing and his continuous support for manned Mars missions adds validity to the cause.

Entertainment and Publishing

The novel *The Martian* has been steadily growing in popularity and a film adaptation will be released later in 2015. Following the box office success of films like *Gravity* and *Interstellar* and the global release of the television show *Cosmos*, it is clear that interest in space exploration is increasing among filmgoers and television viewers. All of these experiences serve to reinforce the public's interest in space exploration and Mars missions, specifically.

Storylines that Resonate with the Public: There are several storylines in particular that resonate with the general public and increase their interest in Mars exploration:

Human Risks of Manned Missions to Mars – Can We Survive the Trip? The number of media stories released about Mars One and Inspiration Mars have injected into public conversation the subject of the impact to the human body of a trip to Mars. When the Inspiration Mars team was looking for a couple "past child bearing age" because of the physical risks, this, and the emotional and psychological impacts of such a long journey, became a popular story in the press. Scott Kelly's year-long International Space Station (ISS) mission and the surrounding coverage of the medical tests he is undergoing for long duration space flight has reinforced the interest in this topic.

"Colonizing" Mars – Can We Live There?
Mars One and *The Martian* have sparked curiosity about what would be involved in living on the surface of Mars. Could you survive? What would it take?

Organic Life on Mars – Extraterrestrial Life
The prospect of extraterrestrial life on Mars has captured the public imagination for years. The body of evidence that Mars might have sustained past – or even present – life is growing and this continues to be a popular story in the media. When the public sees progress forward and understands the programmatic and budgetary reality, a vast majority of Americans support NASA and the prospect of human missions to Mars.

Films and television shows can have a tremendous inspirational value for space exploration (many space professionals were inspired by Star Trek), but it is unclear whether these efforts translate directly into major political support or whether the public see these films/programs purely in the realm of entertainment.

The Administration and Congress

While policy statements, legislation, and other comments are widely scrutinized within the space community, other than infrequent major policy statements by the President of the United States (President Obama: April 15, 2010/President George W. Bush: January 14, 2004), it would appear (based on mainstream news stories) that other statements by the President or Congress have little impact on public perception.

Budgetary Context and Technical Reality

Perhaps the biggest hindrance to building consistent support is based on public perception of what missions to Mars would cost. In the recent Affording Mars Workshop [http://www.exploremars.org/affording-mars] as well as in a workshop held by The Planetary Society consensus is building that affordable and sustainable Mars missions are now viable. In contrast, pundits have suggested unfounded mission costs projected as highs as $500 Billion to 1.5 Trillion. Despite the fact that these numbers are not based on any current mission concepts, such numbers continually reappear. The public also has an inflated perception of the NASA budget. According to the Mars Generation Survey, Americans on average believe that the NASA budget accounts for roughly 2.5 percent of the federal budget (more than five times the actual budget level).

Accuracy and Impact of Public Polling

Scientific polling has shown that there has generally been strong public support for space exploration over the past few decades, but that support levels appears to waver when cost, social programs, and other variables are inserted into surveys.

Examples of recently conducted polls include:

a. Monmouth University Poll 2015 - [http://www.monmouth.edu/polling/MUp79_7.pdf]
   - 51 percent feel that spending should be increased on the space program
   - 42 percent believe funds should be spent on sending crews to places like asteroids, the Moon, and Mars.

b. Mars Generation Survey 2013 - [http://www.exploremars.org/wp-content/uploads/2013/03/Mars-Generation-Survey-full-report-March-7-2013.pdf]
   - 75 percent of Americans believe that NASA's budget should be doubled
   - 71 percent of Americans believe that humans will walk on Mars by 2033

As can be seen in the examples above, the favorable polling numbers are significantly higher in the 2013 Mars Generation Survey than in the 2015 Monmouth poll. Did public support erode that much in just two years? The answer to this question is almost certainly no. As with the vast majority of polls, the answers can be largely swayed by the way the questions are asked as well as public perception of the topic and preconceived notions about the cost of space exploration. The Mars Generation Survey provided budgetary context for the participants - something that the Monmouth poll did not do. The Monmouth Poll implied that Mars exploration is expensive – without any additional explanation. When participants in the Mars Generation Survey were provided with the current NASA budget level, over seventy percent of poll participants supported Mars exploration.

Recommendations

In the case of human missions to Mars, reality is the best ally for building strong and consistent public support. Fictional representations can help, but the space community needs to do a better job at translating excitement about movies into support for actual missions to Mars. Facts are the best ally for maintaining public support of a human exploration program to Mars.

- Dispel the $1 trillion myth: Human missions to Mars should only cost a fraction of this amount.
- Better story telling: NASA and the space community need to better explain a clear path to Mars and how current programs will advance that path.
- Strengthen Hollywood partnerships: NASA and the space community regularly collaborate with the entertainment industry, but these ties need to be strengthened to amplify the messaging for human missions to Mars. When a major film (such as The Martian) is released, the space community, Hollywood, and other players need to find ways to harness public interest in the film to build support and excitement about actual missions to Mars.

EXPLOREMARS.ORG

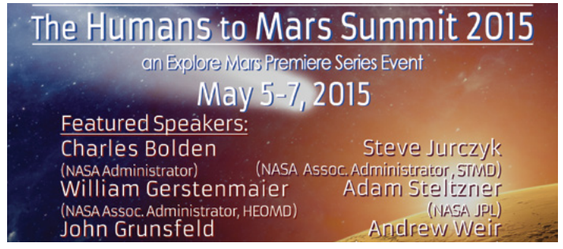
Who We Are and What We Do

Dollar for dollar no other space exploration non-profit accomplishes more than Explore Mars. While others talk about Mars exploration, Explore Mars advances the cause of sending humans to Mars through concrete programs and projects.

Our impact and influence in advancing the goal of landing humans on Mars has been unquestionable. But our most significant work is about to unfold, as we continue in 2015 to expand and accelerate our numerous programs and projects and we bring space stakeholders, policy makers, and others together to tackle the tough issues that have frequently divided them.

THE PREMIERE SERIES EVENTS

- Humans to Mars Summit (H2M): The preeminent gathering to discuss the goal of sending humans to Mars.
- Mars Affordability and Sustainability Workshops: These workshops assemble many of the important individuals who will be tasked with getting humanity to Mars, including representatives from industry and commercial sectors, NASA, academic and scientific institutions, and the political sphere. The assemblies will open dialogue on affordable and sustainable plans for a humans-to-Mars program.



CULTIVATING THE FUTURE of SCIENCE INTIATIVES

- Teaching Mars Workshops: These workshops will bring science educators and space professionals together to brainstorm the integration of Mars into the classroom.
- H2M Webcasts: In 2014, over 1200 schools around the U.S. and Europe viewed the webcast of the Humans to Mars Summit. In 2015, our goal is for 3500-4000 schools to view the webcast.

BE BOLD TECHNICAL PROJECTS

- Time Capsule to Mars Project (TC2M): The first student-led robotic mission to Mars to advance new technologies, conduct important scientific research, and inspire the world.
- Exolance: A project to develop penetrator probes to get below the Martian surface with the goal of conducting unprecedented scientific experiments, including the search for life on Mars.

TC2M
TIME CAPSULE TO MARS

POLITICAL OUTREACH and POLICY RECOMMENDATIONS

- Mars Day on the Hill/Legislative Blitz: Several times a year we lead groups of ordinary citizens to Capitol Hill to educate members of Congress about the importance of human missions to Mars.
- Congressional Briefings: At least twice a year, Explore Mars conducts brief ing sessions and panels on Capitol Hill to educate members of Congress as well as their staff. Policy-makers, and others.
- Relationship building: Explore Mars is building working relationships with members of Congress, Congressional staff. And other policy-makers. We will accelerate these activities in 2015 to enable our elected officials to make decisions based on solid information

UPCOMING PROGRAMS

- Mars White House Initiative: Explore Mars will connect with Presidential candidates to ensure that they are aware of the importance and realities of U.S.-led human missions to Mars.
- International Collaboration: There is a growing consensus that human missions to Mars must be U.S.-led international missions. After making significant progress in impacting U.S. space policy, Explore Mars will begin efforts to build support for humans-to-Mars with our international partners

The Humans To Mars Report 2015

an Explore Mars Publication