Ceres Robotics & Mars Institute
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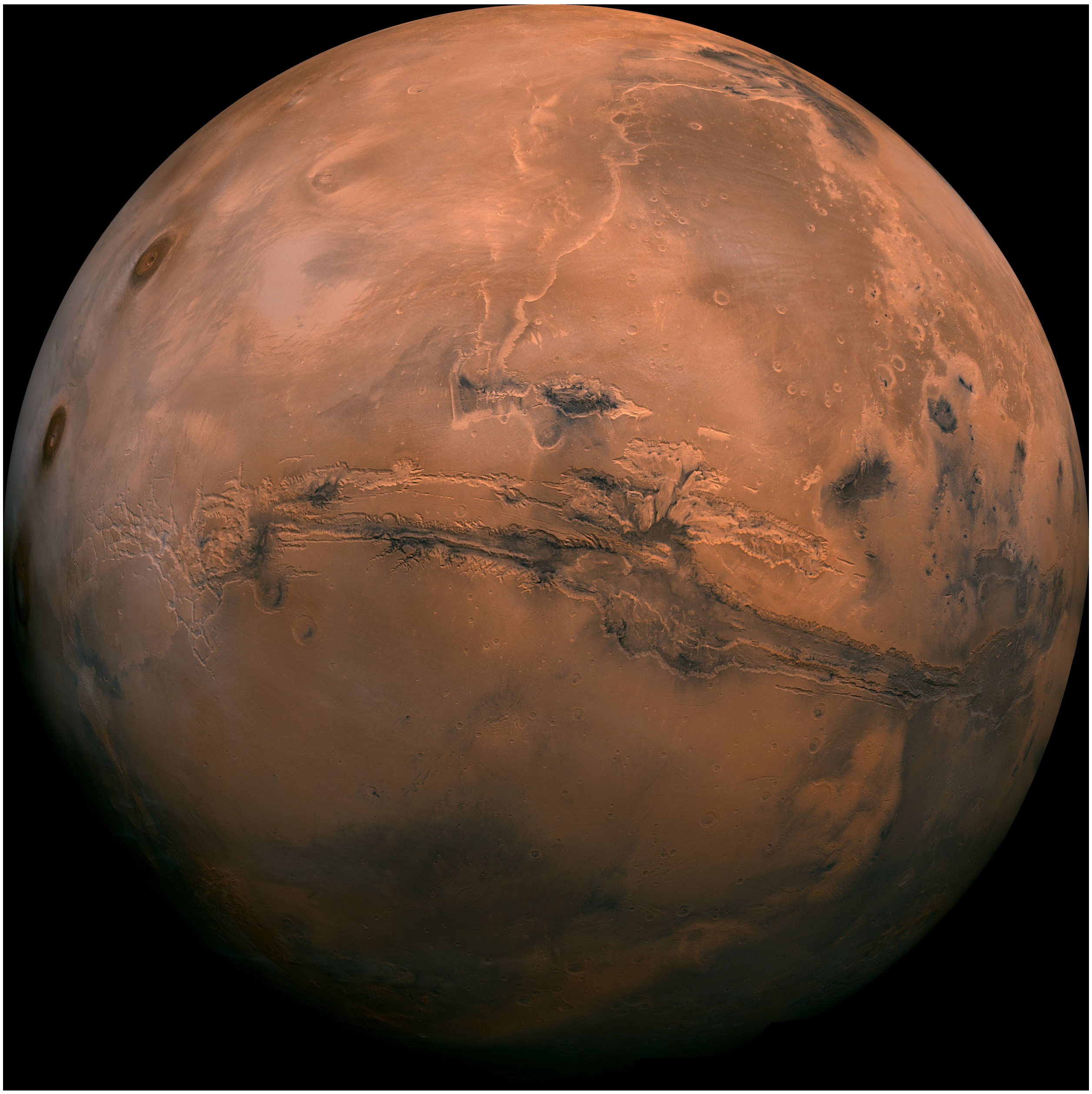
Mars Human Precursors:

ePanel Report

August 22-26, 2016



Executive Summary

A virtual panel was held August 22-26, 2016 to explore essential precursor Mars surface activities which would be compelled by a 2025 Human landing on the surface of Mars. We assumed precursor missions on 26 month windows beginning in 2018. This is the report on that panel's inquiry. The discussion quickly focused on detection of any extant life on Mars, especially at the site of the human landing. With current technologies and current understanding of the scope of possible biological activity there is no single instrument which can convincing eliminate the presence of life on Mars. And because of the distribution of possible niches for life in the Mars environment a given landing site will necessitate multiple measurements with multiple instruments. The panel mostly believed that this life detection investigation should be begun in precursor missions and be continued after the arrival of human crews. Specific instruments for initial and later investigations were discussed. In addition, the topics of best containment strategies for both human brought organisms and restricting exposure to any extant Mars biology were discussed. Also touched on were approaches to accessing water both as an investigations of science and as an important resource for human exploration. The panel explored understanding the toxicity of the landing site's surface materials and the need to demonstrate appropriate mitigation (e.g., chemical treatment of perchlorates) to prevent harm to human crew.

One conclusion from the panel was that there is a need to address the possibility of extant biology on the Mars surface by flying appropriate tools as quickly as possible.

This ePanel was sponsored by Ceres Robotics and currently has neither encouragement nor approval from SpaceX or NASA. Although for this exercise we used SpaceX dates the results are applicable to any near term human missions to Mars. Ceres Robotics is a New Space company that supplies affordable robots, robotic mechanisms and software systems in support of surface exploration.

Outline

Introduction

This virtual panel on essential precursors to a near-term Human Mars mission was managed as an ePanel.

An ePanel is analogous to a conference panel except that it is virtual (in the sense that participants are not required to be in the same room), asynchronous (in the sense that ePanelists are free to read the questions and comments and then respond anytime during that day), and all communications for the panel come through a single ePanel moderator. All communication is via email which offers a distinctive advantages of the communication being succinct, the retracing of the same ground is easy to avoid, there is time for the ePanelists to consider answers and the workload for ePanelists is light. Operationally, each morning ePanelists received an email with a summary of the previous day, new questions, and a request to respond by that evening.

It is important to remember that virtual panel (i.e., ePanel) is foremost a panel (similar to one that might be held at a conference) with all the advantages and disadvantages that all panel have. The big advantage of this ePanel activity is that it gets to crucial issues very quickly. It will take only a moment to have it become apparent when the emperor has no clothes. What this ePanel inquiry is not is an in-depth investigation of a topic as for example occurs in NASA's NESC investigations, nor does it have the broad based community buy-in that occurs in the various NRC's decadal studies, etc.

And as with all panels the participants are asked to give quick, personal evaluations that address the essence of the issues being discussed. All opinions expressed in this report are personal, technical and scientific evaluations and are not to be construed as the views of any employers nor funding sources.

The Problem Addressed

SpaceX has announced a plan to land humans on in Mars 2025 and to land payloads onto the Mars surface at each 26 month opportunity starting in 2018. A similar timeline may be pursued by other players.

For this ePanel the specific inquiry was: if humans do land on Mars in 2025 what do we absolutely need to know from the surface of Mars before that time and specifically what measurements and demonstrations need to be done with the 2018 and later precursor landers to make that possible. For convenience in this inquiry we assumed as givens the dates of a Mars surface lander in 2018 and the date of initial humans landing on surface of Mars in 2025.

This exercise is sponsored by Ceres Robotics and currently has neither encouragement nor approval from SpaceX or NASA. Although for this exercise we used SpaceX dates the results are applicable to any near term human missions to Mars.

ePanel/eAudience Technology

The ePanel/eAudience methodology that we used was invented by Stan Rosenschein and Michael Sims while exploring how to support collaboration among distributed technical teams as part of NASA Ames work on collaboration and Rosenschein's work at Branchtime Technologies. The results can be impressive in terms of the quickness and depth an ePanel can attain in examining fundamental concerns. Mainly that productivity is a consequence of the high quality of the ePanelists and this week's panelists have been superb. The driver of the quality is the enthusiasm and knowledge of the ePanelists for the topic.

The ePanelists for this inquiry were:

Christopher McKay (NASA Ames)

Carol Stoker (NASA Ames)

Margaret Race (SETI Institute)

Andrew Schuerger (University of Florida)

Penelope Boston (NASA Astrobiology Institute)

Pascal Lee (Mars Institute; SETI Institute; NASA Ames)

Charles Cockell (University of Edinburgh; Ceres Robotics)

Michael Sims (moderator) (Ceres Robotics; Mars Institute)

Top level issues from the ePanel exercise

There is a great deal that needs to be tested and evaluated on the Mars surface on very tight timelines to be properly prepared for a near-term Mars mission. Clearly a mission within a decade can be considered near-term although even a considerably later mission will require expedience and a focused effort.

As one would anticipate from a panel, opinions were more strongly presented than traditional in a journal publication. The ePanelists were chosen for their expertise in extant biological systems and the relevance of that to planetary exploration. The Viking landers, the first successful landers on Mars, carried life detection experiments. Although there was ambiguity at the time, today those experiments are widely believed to have shown purely chemical reactions and offer no definitive clues to Mars having extant biological activity. Since that time there have been a highly successful series of observations from Mars orbit and robotic work on the surface which have clarified important parts of the geological and geochemical history of Mars. In addition, there has been important progress both in laboratories and in field science on Earth.

What has been lacking and is poignant for his inquiry is the lack of follow up experiments focused on the search for extant life on Mars. The combination of a 40 year gap in these Mars surface experiments and the essential role those surface life search experiments to the upcoming proposed missions is troubling. A possible explanation for this research gap might be a lack of belief in the reality of human missions to Mars in our lifetimes and hence pushing off essential precursors needed for those human missions might have seemed harmless enough. That strategy would allow the politics of short term scientific priorities to play itself out over the intervening time.

Hence, the topic of this ePanel and its intent to bring the most compelling needs to the forefront. However, as will become clear, there are a number of clear and pressing issues that need to be addressed as soon as possible.

Primary concerns:

Let's begin by listing what have surfaced as the primary concerns.

- Crew safety
    - Dangers to crew from exposure to surface materials and toxic chemistry
    - Dangers to crew from possible pathogens
- Contamination of Mars surface by crew transported organisms from Earth
- Danger to Earth from return of (unlikely but possible) pathogens that are damaging to Earth's biological balance
- Availability of resources useful for human activities including life sustaining materials
- It will not be possible to fully demonstrate the absence of life on all of Mars in any near-term basis unless we find overwhelming evidence of its existence. Scouring the planet widely in this search is likely to be a slow process. This is probably the highest <u>scientific</u> goal for Mars exploration in the long term and it is reasonable for this science exploration be concurrently with the expansion of human presence on Mars. However, unlike the Moon, Mars does theoretically have many possible niches for life and hence as we continue the exploration of Mars we must also continue the search for extant Mars life far into the future.

Suggestions coming out of this ePanel:

We as a panel make the following suggestions. These suggestions only represent the initial gauntlet thrown onto the ground and further in depth evaluations are essential for all of these points.

- If possible land all future precursor missions to the single site of human landing. In addition to the value to future explorers of landed resources at this site, this also gives the best chance of evaluation of the local toxicities and a search for any extant Mars organisms at that site.
- There are no tricorders for life - even on Earth but especially for life that might have a distinct genesis. We need to exercise a number of different instruments on the Mars surface to look for indications of extant life at the landing site. Those instruments need to be applied at a number of areas (niches) around any landing site. Confidence will grow in our outcome as the number of tests and sites increase. Although after 40 years we now believe we understand the Viking life experiments results we need to be prepared for future surprises and uncertainties to come with our experiments. This leads to a preferred strategy to treat these life-detection instruments as an ongoing development (across precursor and human missions) of more refined instrumentation in search of indicators of extant life.
- Until we understand the extent of extant life on Mars (if it exists at all) then one reasonable approach is to exercising a zoned approach to planetary protection.
- We need to characterize the chemistry and especially toxicity of the surface and near subsurface materials at the landing site. We also need to demonstrate techniques for mitigation of those toxicities that are compatible with human crew use and safety.
- Resource needs for the crew and minimizing the burden of keeping a crew safe are parameters to be evaluated in the base site selection. If the case can be closed on pumping water and oxygen and other trace gases out of the atmosphere then that approach has the advantage of ease of crewed operations and relative location independence of the base landing site.
- NASA should conduct a (directed) near term Mars life detection mission with results available in time to influence a Mars 2025 Human landing.

Although there was consensus on the importance of life detection experiments on Mars prior to human arrival and for the importance of planetary protection, there were differing opinions among the ePanelists on the timing and strategies for those endeavors.

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ePaneists closing statements:

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Next we have the closing statements from the ePanelists.

Penelope Boston's closing statement!

I endorse many but not all of the comments of the other panelists. Additionally, I would emphasize the following.

1) The best site for a near-term human mission is likely not to be the best site for science in general, and astrobiology in particular. So, what we know from previous and immediately upcoming missions will not be specifically applicable to the human site except by good fortune. The picture we will have will necessarily be piecemeal.

2) The notion that on one more mission we can somehow crack the issue of whether there is life right there at the potential human landing site is frankly delusional. It is worth looking at the laundry lists of this, that, and the other experiments or approaches that others have advanced in this discussion, but the results will be extremely preliminary and any attempt to promote them as definitive would be illegitimate and essentially laughable. We do not yet have tricorders. And investigating the presence or absence of life in any extreme environment is a massive and cumbersome labor even here on Earth.

3) In my view, the only sane approach to planetary protection concerns surrounding human presence is a zoned approach as described in the Pingree Park workshop document, Criswell et al 2005. This general principle works on Earth in the field, in hospitals, in disease outbreak zones, and in BSL-4 containment facilities. And it will work, probably sufficiently, on Mars.

4) One critical set of experiments and modeling efforts that we need surrounds the fine scale particulates of the regolith. Consequences of this dust are multifold; 1) the human health consequences of dust that is potentially chemically very active, 2) engineering complications from fine particulates probably typically carrying a lot of static charge, and 3) our ignorance of the dust propagation in Martian winds and what the survivability of microorganisms rafting on such particles might be for Planetary Protection concerns. We identified this as a major area of uncertainty in our reassessment of Mars Special Regions, several years ago (Rummel et al 2014).

Margaret Race's closing statement:

Given a human landing in 2025, please respond with your final/summary comments on what is essential to do in precursor missions to that.

For Planetary Protection planning -- fill the science knowledge gaps about

--martian landing site environmental conditions (soil chemistry; demonstration of 'no-life' in surface materials (so OK to land there);

--natural dispersal of martian surface materials (dusts)-- locally and over time; and

-- survival/ sterilization of human associated microbes under Mars surface environmental conditions (complementary research in analogues/simulators on Earth?)

and (technology)

--demonstrate/test telerobotics for sub-surface drilling and sample containment & sealing? (important for both science and planetary protection purposes)

Andrew Schuerger's closing statement:

(1) Your summary above about switching the emphasis from “basic science questions somewhere on Mars” to a highly focused mission to the “selected human landing site” is a key paradigm shift that must be embraced in order to begin generating data that is more relevant to assuring the safety of the human crew. This does not have to be viewed as an abandonment of basic science questions elsewhere on Mars. We must do both.

(2) A precursor mission should select payloads that are best suited for answering if there is a geochemical or biological risk at the landing site. Such a precursor mission cannot hold all of the potential payloads and technology demonstration projects that we can envision. Thus, we must focus on crew safety first, and then technology demonstration payloads second.

(3) The first-order priorities should be (a) detection of a viable and extant microbiota at the landing site in the soil (regolith sampling), (b) detection a viable microbiota in the globally distributed aeolian dust (air sampling), and (c) exposing terrestrial prokaryotes and eukaryotes to actual Mars regolith and aeolian dusts to confirm non-biological safety issues. Associated with the interpreting these biologically oriented experiments, soil chemistry and the search for organics are also very critical, and thus, at least two additional payloads on soil chemistry and SAM/TLS like assays are suggested.

(4) This can be accomplished within the time frame outlined to land humans on Mars in 2025 only if government and industrial partners agree to fast-track the effort in a collaborative manner.

Carol Stoker's closing statement:

The most essential job for precursor missions is to search for signatures of extant life on Mars using the best methods that can be flown.

It is a scientific fact that meteors found on Earth have come from Mars. It stands to reason that Earth has already been contaminated by martian microbes if they exist, but that may have happened long ago and evolution did not stop on either planet since then. So there is still risk that a new introduction of microbes from Mars to Earth could cause problems. The search should occur in the most habitable places that we know of, so that an evaluation that there is no life is of the strongest possible nature. If the data suggests that there may be life remaining on Mars, then I think a lot of proof will be needed that it poses no hazard to Earth before humans should be allowed to land on Mars with missions that plan to return to Earth. That proof could be accomplished with sample return of the samples that contain life, brought into a biohazard containment facility on Earth and tested, tested, tested. Only then if tests show that there is no risk, should humans be allowed to land on Mars.

Charles Cockell's closing statement:

The first human missions obviously need to support humans, so clearly that's the first priority and experiments that support that goal in precursor missions are essential. Also essential is life detection to determine whether there is a risk to humans and to continue the quest to search for life as an excellent scientific question that will be a core human activity on Mars.

Since many experiments can be on the order of a few kgs or less, with the capacity of a Dragon X there seems to be no reason why an extensive payload of precursor experiments including soil toxicity testing, oxygen and water extraction from the atmosphere and life detection instruments could not be landed for a modest tens of kgs.

My recommendation is to take the ePanels ideas, come up with a list of high priority experiments to support human missions, estimate minimum and nominal masses of experiments that would be required for each and then total the mass budget of a single 'Humans to Mars' static payload for a precursor mission - and try and bring it in at 100 kg (or preferably less). Most of these experiments are already out there in one form or another of development and just need minimum mass and costs collected.

Here are just some of the experiments I can think of that have been demonstrated and have experimental rigs that could be developed rapidly and brought together into a payload:

"Humans to Mars" integrated payload for 2018

- Methane production from Martian atmosphere for fuel (~few kgs)
- Water extraction from atmosphere (few kgs)
- Electrolysis for oxygen production (few kgs)
- Soil chemistry and toxicity testing (< 1 kg to several kgs)
- Materials testing and longevity under Martian UV radiation (<1 kg)
- Life detection (many variants of instruments for various missions) (<1kg up to several kgs)
- etc.

References:

(These references are still a work in progress. Quite incomplete and in no particular order.)

Pingree Park workshop document, Criswell et al 2005
https://planetaryprotection.nasa.gov/file_download/62/NASA_PP_HumanExplor)fMars_2005_PingreePk.pdf

Recent NASA workshop on humans and planetary protection:
https://planetaryprotection.arc.nasa.gov/humanworkshop2015/

Mars Special Regions, several years ago (Rummel et al 2014)

http://mepag.jpl.nasa.gov/reports/**Rummel_et_al**_Astrobiology_14-SR-SAG2.pdf

A reference to atmospheric water extraction:
http://www.niac.usra.edu/files/library/meetings/annual/jun00/483England.pdf

Schuerger et al., 2013, Astrobiology, 13(2), 115-131; (2) Nicholson et al., 2013, PNAS, 110(2), 666-671

Moores et al., 2007, Icarus, 192, 417-433

Schuerger et al., 2003, Icarus, 165, 253-276 and Schuerger et al., 2006, Icarus, 181, 52-62).

Dust settling rates during Pathfinder mission:

Landis and Jenkins, 2000, JGR, 105, 1855-1857

McKay, C.P., et al., The Icebreaker Life mission to Mars: a search for biomolecular evidence of life, Astrobiology, 13, 4, DOI:AST-2012-0878, 2012.

SSB report, 2002 Safe on Mars

https://www.nap.edu/catalog/10360/safe-on-mars-precursor-measurements-necessary-to-support-human-operations

Modeling Mars Contamination

http://drum.lib.umd.edu/handle/1903/3366?mode=simple

Some Mars Exploration Plans:

SpaceX

http://www.businessinsider.com/spacex-video-stream-mars-colony-rocket-2016-9

http://www.spacex.com/mars

Lockheed Martin

http://www.lockheedmartin.com/us/ssc/mars-orion.html

http://www.spaceflightinsider.com/organizations/lockheed-martin-organizations/lockheed-martin-outlines-plan-to-send-humans-to-mars-orbit-by-2028/

Boeing

http://beyondearth.com/path-to-mars/?gclid=CjwKEAjw34i_BRDH9fbylbDJw1gSJAAvIFqUhK3QtdbUTET6E0rxOEcqPqDkRoTrcJxTgZ7KhMfgTRoC56Hw_wcB

NASA's Current Plans

https://www.nasa.gov/content/journey-to-mars-overview

http://www.nasa.gov/press-release/nasa-releases-plan-outlining-next-steps-in-the-journey-to-mars

The Planetary Society

http://hom.planetary.org/

http://planetary.s3.amazonaws.com/assets/pdfs/advocacy/2015/Planetary-Society--Humans-Orbiting-Mars-Workshop-Report-%5BFinal.v2%5D.pdf

NASA Mars Reference Mission

https://www.nasa.gov/pdf/373665main_NASA-SP-2009-566.pdf

https://en.wikipedia.org/wiki/Mars_Design_Reference_Mission

http://www.nasa.gov/press-release/nasa-releases-plan-outlining-next-steps-in-the-journey-to-mars

Portree's Humans to Mars - 50 years of Mission Plans 1950-2000

http://history.nasa.gov/monograph21.pdf

The Sally Ride Report

http://history.nasa.gov/riderep/cover.htm

Buzz Aldrin's Plan

http://press.nationalgeographic.com/2015/04/15/mission-to-mars-my-vision-for-space-exploration-paperback/

The Mars Society

http://www.marssociety.org/home/about/mars-direct

Von Braun's Mars Plans

https://en.wikipedia.org/wiki/The_Mars_Project

http://www.astronautix.com/v/vonbraunmarpedition-1952.html

http://www.astronautix.com/v/vonbraunmarpedition-1969.html

http://seradata.com/SSI/2008/09/von_brauns_1982_nasa_manned_ma/

Humans To Mars Report

http://www.exploremars.org/wp-content/uploads/2016/05/H2MR_16_Final_Print_v4i.pdf

Mars One

https://en.wikipedia.org/wiki/Mars_One

Appendix

Below, I have listed the emailing from all of the days of the ePanel. Please take these in the spirit of a conference panel conversations and where you may feel the writers misspoke please permit some leeway. This represents the sausage making but there are definitely some good ingredients that show up.

Monday Directions and Questions:

Format:

The ePanel lasted five days, Monday through Friday. Each day began with a summary and questions from moderator (Sims) before 8:00 AM Pacific time and responses were to be returned by 6 PM Pacific time that day.

Background:

As you know SpaceX is planning to land humans on Mars 2025 and to land payloads onto the Mars surface at each 26 month opportunity starting in 2018. The inquiry for this ePanel will be: if humans do land on Mars in 2025 what do we absolutely need to know about the surface before that and specifically what measurements and demonstrations need to be done with a 2018 lander to allow humans on surface in 2025. In this exercise our discussion we will assume these fixed points: lander to Mars in 2018 & humans on surface of Mars in 2025. Although the validity or our belief in those dates might be an interesting topic for discussion it will not be one of our topics to discuss on this ePanel.

Priming the pump (feel free to ignore/edit/enhance this as you see fit):

A1. Detection of life experiment

A2. Determination of the toxicity of Martian soils and if they have any immediate deleterious effects on people (perchlorates, etc).

A3. removal of perchlorates from soil

A4. Decontamination on Mars surface by UV sterilization test

A5. Producing Martian water by pumping the atmosphere or other water & oxygen sources

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Questions for Day 1 (Monday, Aug 22):

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- What Mars surface experiments/tests do you consider essential to accomplish prior to humans landing on Mars in 2025? Of those surface experiments what do you deem most important to accomplish in 2018 (and state why)? (Optional) What previously suggested experiments do you consider NOT essential?

Please indicate tests required, specific technology (if you suggest one) for doing this testing, and risk associated with failing with these tests).

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Tuesday's Questions and Comments from Monday:

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Summary from Day 1:

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Two primary elements came out of comments on Day 1:

1) Do life detection experiment to understand if there is extant life on Mars of a similar nature to life on Earth.

2) Gain knowledge necessary for a realistic planetary protection strategy for 2025 human mission. I propose for the ePanel that we evaluate planetary protection in it's two separable parts:

2a) forward planetary protection (managing Earth organisms that we take to Mars)

2b) backwards planetary protection (keeping possible Mars pathogens from returning to Earth)

Margaret Race's comments:

A key will be a fuller understanding of Earth originated microbial survival, dispersal and dissemination on Mars (forward contamination). Among the important questions that must be addressed before a 2025 mission are:

What is the potential for survivability and replication of very hardy microbes on Mars-- in dust environments, across Mars, and in biofilms? thus, understanding what natural martian conditions could be biocidal and affect microbial survival, growth and evolution in Mars-type environments-- would be important.

Also, it will be important to understand what happens to windblown dust on the Martian surface-- where might it go-- Essential experiments to consider would be those that focus on gathering data on the typical spatial and temporal meteorological conditions that microbes might be exposed to.

Fully understanding martian surface conditions and dust dispersal will be important input to the design of mitigation technologies to minimize contamination associated with future human activities and operations-- as well as to avoid false positive biosignatures or contamination of science collections.

In addition, any experiments or observations that lead to a fuller understanding about the presence and characteristics of brines, special regions, subsurface ices (and other potentially habitable locations and conditions) will also be important information.

Recent NASA workshop on humans and planetary protection:
https://planetaryprotection.arc.nasa.gov/humanworkshop2015/

Christopher McKay's comments:

The most important experiment for 2018 on the path to long term human exploration is a search for life is the surface and close subsurface (~ top 1 m depth) at a plausible landing site. The reason for this priority is 1) both astronaut health and safety, 2) science motivation for the search for life, 3) planetary protection, terraforming, and ethical treatment of aliens.

For astronaut health and safety this search should specifically target Earth-like life - that is life that is biochemically related to life on Earth. For science motivation the search should have the capability to detect life that is elementally similar to life on Earth (carbon structures, liquid water based) but with a alien genetics and biochemistry. Both searches are of interest in terms of planetary protection, terraforming, and ethical treatment of possible alien species.

Carol Stoker's comments:

The most critical robotically collected data that is needed before landing humans is a next generation life detection experimental package landing at the area that the people will land. If there is life on Mars, and it is accessible and prevalent enough for the crew to encounter it, then it is certainly a concern for soil toxicity as a biological agent could interact with the crew, the life support materials and systems, and could pose a hazard to Earth if the crew returns to Earth.

No life detection experiment with negative results can prove the nonexistence of life on Mars. But relatively simple and well known experimental methods are available that could detect the presence of life, and a positive result from such an experiment will of necessity change the whole picture of whether, when, and how to land humans.

Life detection can be done in situ, without sample return. In fact, it is not clear that samples selected for sample return would be likely to be those likely to support or contain life.

Charles Cockell's comments:

I think the planetary protection issues are really complex. I would just assume that humans land with their contaminants and leave it to the PP people to worry about determining inventory on humans etc.

The focus could be on a life detection instrument. The Viking experiment was good, but most of the experiments based on culturing - so the best approach is to look for organic molecules with patterns (Lego bricks analogy from Christopher) and that could be done with things like GCMS and next generation life detection equipment.

I also think that an instrument to characterise the soils in great detail and their potential toxicological effects (perhaps by chemical assay) would be a good experiment to prepare the way for human explorers.

Going for a life detection experiment with a plan to apply that in drilling in a later mission makes sense since the first round gives the opportunity to field test the instrument and then use it with more challenging subsurface samples.

I agree that being able to detect life as a way or seeking indigenous life and monitoring contamination if planetary protection concerns require that is a sensible choice for 2018 so the instrumentation to monitor human influence can be robust for 2025.

Maybe then we should be thinking of a small network of bio monitoring instruments to be deployed in 2018 to seek surface organics/life that would double up as a human microbe monitoring network in 2025.

Additional comments:

Since the surface of Mars (due to UV radiation and low atmospheric pressure) is hazardous or toxic to most known Earth organisms and since there is no current evidence for extant life on Mars it is only prudent to assume that any Mars life will not be global in extent and hence there will be local variability if it exists. That implies that any life detection experiment relevant to humans on the surface should take place at the location of human landing. This is especially true for negative outcomes on detection of life,

Both this argument and the possibility of previously caching materials argues for all precursor and human landings at a single location.

The assumption we are making of a 2025 human landing places strong constraints on what planetary protection activities can be accomplished prior and subsequent to human arrival.

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Questions for Day 2 (Tuesday, Aug 23):

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Forward contamination:

If humans land in 2025 with a couple of hundred kilograms of (or pre-stashed) science instruments is the probability pretty high that we could distinguish life that came from Earth vs. indigenous Martian life regardless of contamination? Evolutionary paths must have (at the least) diverged long ago?

Also it is unlikely that we would land at the single locale of any (possible) extant biology on Mars. Therefore if we unintentionally and locally wipe out that local population by our contamination is that an acceptable risk in your view?

Given the assumed constraint of a 2025 landing by humans are we properly focused on a robust strategy for obtaining planetary protection information to know what needs to be accomplished in 2018? (Our focus here is technical not political.)

It is rare for an Earth species to be able to survive in Mars simulated conditions. Can we avoid taking those hardy species with a Mars crew or are those organisms too ubiquitous?

Margaret Race is expressed a worry about atmospheric conditions blowing around microbial contaminations after human arrival. Clearly we have global scale storm events that raise dust into the atmosphere and we have local events (dust devils and otherwise) which locally distribute material. Presumably microbes or spores are sufficiently small to also be distributed by these mechanisms. Any thoughts on that?

Also, any biological contaminates, such as fecal containers, need to be protected from unintentional distribution such as by rockets exhausts.

Life Detection Instrument(s):

Do we fly an upgraded variant of Viking experiment? Specifically what instruments are being suggested to detect what properties of life?

Soil evaluation:

Suggestions on instruments to do soil evaluation with an eye toward human safety and possible detoxification?

Strategy:

Vis a vis the life experiment it appears given the 26 month Mars departure plan that there will be sufficient time to fly a life experiment on the second launch (2020 in the sequence of flights we are *assuming as a baseline) and a life experiment with a drill in the third flight and still know the results prior to human launch for 2025. Does that make sense?*

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Wednesday's Questions and Comments from Tuesday:

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Brief summary of discussion from Day 2:

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Read the ePanel's discussion at end of today's email. Those ePanelists' comments have been mildly edited by the moderator to keep the discussion on topic. Since those comments are quite lengthy I'll summarize here.

I'm continuing to hold our discussion to only considering a 2025 human landing date. This is a possible date although clearly that date might slip one or two opportunities. However, much of what is discussed will transfer to a slipped date.

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Life Detection Experiments: NASA last did a Mars life detection experiment on Viking 40 years ago. Although since that time there have been many Mars missions doing excellent science I would say there is a consensus that NASA hasn't followed up on the Viking life detection experiments. As a consequence of that 40 year gap in Mars life detection experiments there is now a most difficult task of fulfilling the critical parts of that needed knowledge on an extremely short timeline.

Pascal Lee explore that 'doing less up front life detection experiments' might be acceptable with a corresponding greater risk posture for human missions. Lee suggests, given the closeness of 2025 and preparations required, that it might make sense to do no life detection experiments prior to human landing.

Andrew Schuerger stated that was that there are numerous and strong biocidal factors that make microbial survival and growth very difficult on the Martian surface.

Schuerger doesn't recommending that it is OK to send no life detection missions before 2025. He thinks it is imperative that we DO send life detection missions before 2025. He then went on to say that the approach to send humans to Mars and " and then see what happens…" takes on much greater risk to the astronauts if it is later shown that there is an extant microbiota on Mars. "If there is no extant microbiota on Mars, then the point is moot, but only in hindsight."

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Mars contamination from escaped microbes from human visit: Margaret Race and Joel Hagen worry about escaping microbes being dispersed by Martian winds. Michael Smith stepped in and indicate that to first evaluation that dispersal is a real and possibly significant issue. Local and even global scale distribution via winds of particles in the 1 micron scale is realistic under certain circumstances.

One perspective comes from the work of Rosalba Bonaccorsi (see eAudience comments at end) and colleagues that has examined traces of fecal matter near their field site in the Atacama Desert. They found that the contaminates didn't seem viable after a few days under the Atacama's sun/ UV radiation.

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Water: Pascal Lee suggests that the highest priority is identifying a viable source of extractable (affordably extractable) water and Mars demonstration of a process to do it. There are locations on Mars with repeated occurrences of fog (e.g., Valles Marineris canyon floor, say Noctis Landing) that are probably best for atmospheric water extraction.

One reference to atmospheric water extraction:
http://www.niac.usra.edu/files/library/meetings/annual/jun00/483England.pdf

Alternative strategies for in situ water production include extraction from subsurface ices, landing near surface brines extrusions or processing water rich surface materials. Although these methods are intrinsically more energy efficient all of these process will require manipulating significant amounts of surface materials. That surface material manipulation and processing is possible but will be both a difficult and dirty task.

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Single Landing site: There is a reasonable consensus on the advantages of picking a single landing site prior to 2018 and landing all subsequent missions at that site. Pascal Lee maybe stated it best "we need to focus on the survival of the astronauts AND the long term viability (survival potential) of their landing.

My premise being that we (should) stay for the long term where we first land. Going to a single site can be argued is the best approach re Planetary Protection."

Sending all missions to a single site also has the best chance of any life detection results being relevant to human missions since any such life detection tests are local by their nature..

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Questions for Day 3 (Wednesday, Aug 24):

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Briefly describe the science (~one sentence) of all instruments you would propose for life detection experiment.

Although we would all like it to be possible to do a precursor life detection experiment, please describe your evaluation of the risks associated with not doing so. Can you imagine life detection experiments only done after human arrival? Clearly doing the science of origins may be harder but probably not impossible.

Locations with liquid water or recent liquid water have the best prospects of having viable Martian life. Hence, is it not prudent to keep away from those sites deemed to be the best prospects for having extant martian life in the first human mission and allow those investigations to be done later? Thoughts?

What major issues come to mind that are we missing addressing associated with required precursors to a 2025 human landing?

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Details of responses for Day 2 (Tuesday, Aug 23):

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Andrew Schuerger's comments:

Andrew's comments for Day-1 Questions:

(1) Due to spatial diversity of the Martian terrain, a landing site for the human mission needs to be selected quickly. Such a search must predict a plausibly safe and non-toxic environment based on our current understanding of the Martian terrain (orbiter and rover/lander data). At least 1 precursor robotic mission should be targeted to land at the selected human landing site; 2-3 precursor missions would be better. Then, at least the following 3 experiments should be performed at the landing site.

a. An advanced Life Detection experiment should be designed to (a) search for extant microbial life that might follow similar biochemical or genomic pathways that terrestrial life utilizes for metabolism and reproduction, and (b) the payload must be robust enough to simulate both Mars surface and terrestrial conditions of pressure, moisture, temperature, gas composition, etc. It is not enough to only screen the regolith under Martian conditions (in situ life detection), but also we must confirm that unknown life forms are "unable" to metabolize and grow under more benign terrestrial conditions present in the human habitat.

b. Soil chemistry must be explored at the human landing site in order to identify potential geochemical conditions that might be biotoxic to humans (e.g., concentration of perchlorates might impact human respiratory systems).

c. Soil physical properties are also required to assure that a human-crewed vehicle can land safely because it will be much larger and heavier than all previous missions landed on Mars.

(2) The potential human landing site must also be explored for the potential to contain subsurface pockets of liquid water or ice. This issue gets complex very fast, and the requirement for water or ice are relevant depending on the nature of the human mission. If it is a sprint mission that might last only a few weeks, then landing near a pocket of liquid or solid water is not relevant. However, if the goal is to have the 2025 landing be the first in a long series of missions to establish a permanent human basecamp on Mars (Space-X approach), we cannot afford to land at an inferior location for long-term habitation requirements.

(3) Microbial survival experiments on Earth in simulators gives much needed baseline data for modeling microbial survival, growth, and evolution on Mars. But the simulator experiments can never replace actual data on microbial survival, growth, etc. under actual Martian conditions. Thus, microbial survival and growth experiments of terrestrial life forms genetically engineered with "suicide genes" should be programmed into the precursor missions ASAP. By suicide genes I am referring to genetically modified microbes that require a complex growth-stimulating chemical or nutrient from Earth that would

not naturally exist on Mars. Thus, the risk of global contamination of the directed panspermia experiment is minimal. Such a set of directed panspermia experiments will permit us to study how terrestrial life (e.g., bacteria, archaea, fungi, and eukaryotes like Tardigrades) will respond to Martian surface conditions without waiting for the sample return mission to be completed. Thus, if the Life Detection experiments are negative for an extant Martian microbiota, we still get data on how terrestrial life will interact with the Martian surface.

Andrew's comments for Day-2 Questions:

If humans land in 2025 with a couple of hundred kilograms of (or pre-stashed) science instruments is the probability pretty high that we could distinguish life that came from Earth vs. indigenous Martian life regardless of contamination? Evolutionary paths must have (at the least) diverged long ago?

****If lithopanspermia models are correct, then Earth and Mars have been exchanging biota for at least 3.8 billion years (early stages of life on Earth). Thus, the lineages might be more closely aligned than anticipated. But it is equally plausible that the two biospheres (assuming there is one on Mars) may have been firmly isolated for many tens to hundreds of millions of years. In general, the most devastating pathogens are those that share a coevolutionary history with their hosts. Thus, the further back the last lithopanspermia exchange of coevolving lineages occurred, the ability to distinguish Martian versus Terran life goes up and the potential risks go down. BUT….we must view this suggestion cautiously because we have no other life lineages to estimate the severity of a potential pathogen than our terrestrial examples. It is this "epistemological" crisis for the pathogenicity of life from divergent lineages that is the most worrisome for both forward and back contamination.

Also it is unlikely that we would land at the single locale of any (possible) extant biology on Mars. Therefore if we unintentionally and locally wipe out that local population by our contamination is that an acceptable risk in your view?

****If an extant microbiota exists anywhere on Mars, it is logical that it pervades many diverse ecosystems on Mars. It is unreasonable to think that an extant microbiota on Mars will be composed of highly restricted extremophiles in high spatially constrained communities. We must think of the "ecology of the Martian microbiota" as we would think of our own Terran example. On Earth, there are niches that are very low in both diversity and biomass and there are areas that are rich and diverse in microbial diversity. The same should be expected on Mars.

Given the assumed constraint of a 2025 landing by humans are we properly focused on a robust strategy for obtaining planetary protection information to know what needs to be accomplished in 2018? (Our focus here is technical not political.)

****The planetary protection issues and the human safety issues are not being pursued adequately to answer the biosafety questions that are being raised here. The problem is not a lack of enthusiasm for the work, but it is purely a budgetary issue. The SpaceX and Mars-One approaches are to "….Go to Mars and see what happens…" This approach is very risky if an extant microbial community is present. If there are no unique lineages of life on Mars, then most forward and back contamination issues become similar to the Moon. Thus, in order to gain any reasonable assurance that we can both send humans to Mars and to return them safely to Earth, "serious" funding is needed ASAP to ramp up landers, rovers, and payloads to address these questions.

It is rare for an Earth species to be able to survive in Mars simulated conditions. Can we avoid taking those hardy species with a Mars crew or are those organisms too ubiquitous?

****We have now identified 34 species of bacteria in 11 genera that can grow under stable conditions of 7 mbar, 0 C, CO2-enriched anoxic atmospheres, hydration, and adequate nutrients. The bacteria are from diverse soil and non-soil ecosystems. Many of the species have been recovered from spacecraft hardware, including the internal surfaces of human spacecraft and habitats. Thus, it is very unlikely that human missions and instruments can be cleaned to such an extent to prevent these "hypobarophiles" from being transported to Mars. That said, the Martian surface is still an extremely harsh environment, and most of the bacteria will have great difficulty in proliferating on the Martian surface. [Examples: (1) Schuerger et al., 2013, Astrobiology, 13(2), 115-131; (2) Nicholson et al., 2013, PNAS, 110(2), 666-671.]

Margaret Race is expressed a worry about atmospheric conditions blowing around microbial contaminations after human arrival. Clearly we have global scale storm events that raise dust into the atmosphere and we have local events (dust devils and otherwise) which locally distribute material. Presumably microbes or spores are sufficiently small to also be distributed by these mechanisms. Any thoughts on that?

****I have previously modeled the kill rates of Bacillus spp. under equatorial Martian UV fluence rates to the rate of coverage on lander surfaces by settling dust (see Schuerger et al., 2003, Icarus, 165, 253-276 and Schuerger et al., 2006, Icarus, 181, 52-62). The UVC flux on equatorial Mars is so high, that it is plausible to achieve greater than six orders of magnitude reduction in surface contamination on rovers and landers within 2-3 hours for sun-exposed surfaces. Furthermore, the rate of dust settling is relatively slow; estimated at about 0.28% per sol for the Pathfinder mission (see Landis and Jenkins, 2000, JGR, 105, 1855-1857). Thus, the biocidal kill rate is orders of magnitude faster than the surfaces can be covered by dust. The exception to this statement is if the bioload is located in a protected niches on or within the landers. Then, survival rates can go up to ~100 sols for the undersides of rovers, and perhaps many years on the most shielded surfaces (see Moores et al., 2007, Icarus, 192, 417-433).

Do we fly an upgraded variant of Viking experiment? Specifically what instruments are being suggested to detect what properties of life?

****Life Detection experiments must include multiple methods to detect life processes. Three experiments were flown on Viking, and there have been many suggestions to both upgrade these instruments and to add numerous other approaches. Thus, a Life Detection mission similar to Viking might require up to 6 or 7 approaches to truly rule out, or accept, the existence of an extant microbiota on Mars. We are still arguing about the Viking results some 40 years later. In general, the more life detection payloads using a diversity of approaches the better. But to emphasize my comment from Day-1, the life detection instruments need to be able to incubate the samples under both Martian and Terran conditions. The first to search for an extant microbiota under Martian conditions, and the latter to confirm the safety of the Martian fines to human astronauts.

Suggestions on instruments to do soil evaluation with an eye toward human safety and possible detoxification?

***** Soil chemistry is a critical component for life detection experiments on Mars. Thus, payloads are required that precisely estimate soluble ions, pH, EC, Eh, CEC, and biotoxic elements. If terrestrial life forms are sent with "suicide genes" to evaluate how Terran life interacts with Martian regolith, these factors will be important in interpreting the results. We need to differentiate between negative growth that might be due to soil geochemical issues alone versus potential microbial pathogenesis from an extant microbiota.

Vis a vis the life experiment it appears given the 26 month Mars departure plan that there will be sufficient time to fly a life experiment on the second launch (2020 in the sequence of flights we are assuming as a baseline) and a life experiment with a drill in the third flight and still know the results prior to human launch for 2025. Does that make sense?

****The timeline for a safe and successful launch of a human mission to Mars in 2025 is VERY tight. If 1-3 precursor missions are planned, the timeline might have to be extended to be no earlier than 2030. Thus, one of two pathways seems open to us: (1) "Go to Mars and see what happens"…a.k.a. the SpaceX and Mars One approach, or (2) let's properly design, build, and fly at least one precursor mission (2-3 missions would be better) to pretest the safety of a potential human landing site.

Carol Stoker's comments:

Viking landed on Mars 40 years ago and it performed the only life detection experiments ever attempted. At the time the misión was planned, our understanding of Mars was very limited and there was a widespread belief that finding life would be easy. Although the experiments were very sophisticated for their era, the approach in modern hindsight appears to be quite flawed. The Viking experiments attempted to culture martian organisms. Although it was not known at the time, most organisms can't be grown in culture. Still, all of the 3 experiments gave results that resembled those that would be expected from a biological signature, in broad outline but not in exact detail. The most conservative interpretation of the results was that the responses were due to chemical reactions in the soil. However, one of the main arguments against a biological interpretation was the non detection of organic compounds in the soil by a fourth instrument, the Viking GCMS. We now know that any organics present would likely have been combusted with perchlorates in the soil during the volatile release stage.

During the decades after Viking, many years of lab work were performed trying to duplicate the results of the Viking biology experiments in the laboratory by chemical means with little success. The big surprise came, which helped explain a lot about the Viking results, when the Phoenix mission discovered perchlorates on Mars in 2008.

Forty years after Viking, it is time to try again to search for life on Mars. The Icebreaker Life mission (McKay, C.P., et al., The Icebreaker Life mission to Mars: a search for biomolecular evidence of life, Astrobiology, 13, 4, DOI:AST-2012-0878, 2012.) proposes a new approach to search for life on Mars. The mission proposes to go to an environment where there is near surface ground ice that would have been warm enough to allow growth within the last 5 million years, and experiences those warm conditions periodically and has throughout Martian history. In other words, Icebreaker would go to a likely place to find life. The mission would drill into and sample the ground ice. The Icebreaker payload includes an instrument called SOLID, for Signs of Life Detector. This instrument uses the technology of immunoassay to search for biomolecules that are common to Earth life. This approach is most likely to detect life that is biochemically similar to life on Earth. Biochemical similarity could be a result of the fact that conditions on early Earth and Mars were similar, but because Earth and Mars have exchanged material over the aeons, they could also share common life.

Other instruments in the Icebreaker payload help to characterize the soil toxicity and presence and abundance of salts and oxidants, and to do a broad general characterization of organic compounds using a method that does not heat the sample. This method uses a laser to desorb the volatiles and is not affected by the presence of perchlorates.

Icebreaker is optimized for successful detection of life because the mission goal was determine if there is life on Mars. What you are describing is something to more convincingly rule out life. I think the former is more valuable, because a negative result there would imply that the less habitable environments have an even lower probability of life. But the attractive environments from a human exploration standpoint are the midlatitude ice deposits, and these may also be habitable environments for the same reason that the Phoenix landing site is, only there the ground ice is somewhat deeper under dry soil, but not deep enough that humans will not disturb it. Furthermore, after humans land on Mars, it is contaminated and any further search for or detection of Martian life will always be suspect that it was just terrestrial contamination. So from the point of view of science, it is critical that search for life be performed before humans land.

The best way to convince the PP office that there is no risk to life on Mars is to have good evidence that even the most habitable environments don't have a biological signature.

That said, it would be possible to use SOLID to scoop up surface soil and assay it for biomarkers. In that case, the meaning of a negative result would be that no biosignatures that SOLID could detect were present at the detection sensitivity of the instrument. That would not, in itself, prove that no viable microbes exist in that soil at a level too low to be detected.

The surface soil is not an environment conducive to microbial growth. The only places where it could occur would be where deliquescence is pulling in moisture during the high humidity conditions. That appears to be happening in a variety of places. Deliquescent perchlorate is not habitable, but other salts like chlorides can be.

Icebreaker used a carbon copy of the Phoenix Wet Chemistry Laboratory to assess soil. That instrument was originally built with HEOMD funding to assess soil toxicity. There have been subsequent developments of new instruments that expand on what WCL could analyze. WCL discovered perchlorate on Mars, but it was designed to detect nitrates. The nitrate electrode was more sensitive to perchlorate than nitrate but nobody ever suspected perchlorate would be present.

Pascal Lee's comments:

So far, I find myself mostly at odds with most of the previous input. I don't think that a life detection experiment is a priority at all IF we plan to land humans by 2025. But is that your question?

I think that priority should be placed on identifying a viable source of extractable (extractable affordably) water and a process to do it. It's a longer discussion for sure, but based on your straight-forward question and premise, that would be my answer.

If we assume humans landing on Mars in 2025, we need to focus on the survival of the astronauts AND the long term viability (survival potential) of their landing site (my premise being that we (should) plan to stay for the long term where we first land). Going to a single site is also, by far, the best approach re Planetary Protection.

Also, I did not say that life detection is not important. Your question, I thought, was about the TOP priority, right? Top priority is crew survival in both short and long term. That means finding extractable water where we would land (and stay).

Michael Smith's comments:

Atmospheric distribution of microbiota and spores seems like a valid concern to me. We know that dust aerosols (which have typical radii of about 1 micron or so) can stay aloft for weeks at a time if they get injected high into the atmosphere (say above 10 km) as happens in even regional scale dust storms. If the microbes are of similar size and can also remain suspended in the atmosphere for days or weeks then they will readily be widely dispersed by winds. Even if the microbes remain suspended for a short time (minutes?) it seems like the wind could easily transport them outside the immediate containment area around a landing site. From the spread of dust storms, we see that dust is spread regionally in days and globally in weeks. It would not require a global scale dust storm to spread dust over large distances. Once microbes are lifted from the surface via dust devils or other surface or convective winds then prevailing winds will carry the microbes for as long as they remain suspended. So yes, I agree that better understanding of near-surface meteorology is important (especially for lifting processes), as is the transport given by the general circulation.

<overnight>

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Thursday’s Questions and Comments from Wednesday:

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(Previous) Questions for Day 3 (for Wednesday, Aug 24):

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Briefly describe the science of all instruments you would propose for life detection experiment.

Although we would all like it to be possible to do a precursor life detection experiment, please describe your evaluation of the risks associated with not doing so. Can you imagine life detection experiments only done after human arrival? Clearly doing the science of origins may be harder but probably not impossible.

Locations with liquid water or recent liquid water have the best prospects of having viable Martian life. Hence, is it not prudent to keep away from those sites deemed to be the best prospects for having extant martian life in the first human mission and allow those investigations to be done later?

What major issues come to mind that are we missing addressing associated with required precursors to a 2025 human landing?

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Brief summary of discussion from Day 3:

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Again the meat of this discussion is in the ePanelists comments at the bottom.

The detection of possible Mars life remains the most discussed issue. Although some ePanelists felt it could be postponed till human arrival most ePanelists have argued that the detection of possible Mars life is too important to crew safety and crew surface procedures to wait until that time. In spite of much excellent work on Earth we must respect what we haven't yet demonstrated how to effectively do life detection on Mars. The most prudent and fault tolerant strategy is to fly a sequence of more and more capable life detection instruments on every Mars landing going forward. This represents a case where a overwhelmingly compelling scientific investigation (what would be more exciting than the discovery of non-Earth life!) is also a critical component in assuring the safety of human crews. Although most believe the existence of viable biological agents on the Mars surface is most unlikely, the Mars subsurface is expected to contain areas that are believed to be compatible with life as we understand it. We need to know if there exist life in any of the niche's we visit and if so we need to know the impact that that life could have on human crews and for a healthy future for human Mars inhabitants.

Although we have previously discussed forward contamination of Earth life being transported to Mars, today Carol Stoker described the issues associated with backwards contamination of possible Mars pathogens contaminating Earth. See her words toward the end of the page.

Again for crew safety we need to understand the chemistry of the martian soils we encounter. Specifically, we need to understand the characterization of the salts in the soil including perchlorate and other oxychlorides. Given that detailed characterization at the landing site we then need to understand the process and procedures of detoxification. That detoxification could offer surprises (as Mars often does) so it is prudent to verify these detoxifications prior to human crew arrival. This represents a multi-mission approach to robustly being prepared for these hazards.

There seems to be somewhat of a consensus on repeated flights returning to the same site. There is scientific and in the long term habitability advantages to the Mars base being near subsurface ices or possibly other water sources. This raises a suite of issues associated with protection of the crew and protection of possible extant life from Earth contamination. In addition, these sites can be excellent targets for scientific life detection. In other words in choosing a base site near water resources there are advantages (water as a resources and good for life search) and disadvantages (good for life so may be safest to stay away). We will explore this more in today's questions.

The ultimate priority of all of these precursor activities is to contribute to crew safety in the initial and subsequent human Mars missions. Wonderful science will be done along the way, of necessity, but the ultimate driver in precursor missions needs to be those investigations which best inform and enhance human crew protection. Of equal importance is the assurance, via clear experimental demonstrations, of no harmful back contamination to Earth. Also, if we find extant Mars biological activities we need to strive to preserve it in the best ways we can.

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Questions for Day 4 (Thursday, Aug 25):

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If one could only fly one life detection instrument in the first opportunity (2018) what instrument would that be and why? (Assume other instruments are flown on other opportunities.)

If you had a human crew contributing to the life detection or soil chemistry at some stage during the investigation what would you do differently or what instruments would you use that you haven't been considering? SEM for microbial visualizations?

Since a negative result for extant life detection from a sample return mission gives little information on that issue what is the importance of a sample return mission for our assumed baseline scenario?

During Apollo space suits, astronauts and cabins were inundated with surface materials from the Moon. For Mars we know we will have a raining down of fine materials over time on all exposed objects. Since perchlorates and possibly other Mars surface materials can be harmful what can we do prior to humans landing to better understand how to mitigates these surface hazards?

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Details of responses for Day 3 (Wednesday, Aug 24):

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Carol Stoker's comments:

Briefly describe the science (~one sentence) of all instruments you would propose for life detection experiment.

Determine the presence of large complex organic compounds that are too large to be delivered to Mars by comets and meteorites. Determine if there is a chiral bias to any amino acids detected.

Although we would all like it to be possible to do a precursor life detection experiment, please describe your evaluation of the risks associated with not doing so. Can you imagine life detection experiments *only done after human arrival? Clearly doing the science of origins may be harder but probably not impossible.*

I think that the risk to not doing an evaluation of life on Mars prior to sending humans is very high, unacceptably high unless the crew will not be returned to Earth. Risk assessment is done systematically at NASA where both the probability of the occurrence and the seriousness of the consequences are evaluated. While the risk may be low (and because we have done no post Viking experiments, we don't have any good means to evaluate the risk), the consequence is infecting Earth with something deleterious and the consequences of that could be catastrophic. The habitability of our own planet for human and animal life is maintained by a well-mixed and balanced microbial biosphere. An alien invader microbe could upset that balance, much as our own terrestrial ecosystems are disturbed and many times their natural inhabitants die off when new species are introduced deliberately or inadvertently. Any microbes that have adapted to life on Mars are living under extremely harsh conditions. Better conditions may not kill such microbes but rather allow them to explode. This is a situation with unpredictable and possibly disastrous consequences. We simply can't afford to take a risk like that and regardless of what some company may like to do, or how low they think that risk is, the rest of the inhabitants on Earth are not likely to agree with them. However, there is one way to avoid that risk if they are determined to send humans to Mars without first evaluating it, and that is to allow only one way crews. If crews want to choose Mars as their place to live (and die), that should be their right.

Locations with liquid water or recent liquid water have the best prospects of having viable Martian life. Hence, is it not prudent to keep away from those sites deemed to be the best prospects for having extant martian life in the first human mission and allow those investigations to be done later?

This assumes that one has determined in advance where those places with liquid water are. The Recurring Slope Linea are strong evidence of current water flow on Mars. A plausible explanation for them is that they are caused by salt deliquescence. They are very widespread, occurring even at equatorial locations. They are seen on steep slopes, but it is not likely that the deliquescence only occurs on steep slopes, but rather that is where the consequence may be flow. Data from the Curiosity Rover REMS weather station experiment combined with the Neutron Spectrometer on the rover have been interpreted to indicate that there is a diurnal cycle of water being drawn into the soil. The Phoenix mission showed a similar phenomenon. This could be a source of water for life occurring almost anywhere. If we don't know where life is, we also don't know where it is not. It is hubris to think that we can land in a sterile location and just stay away from the risk.

What major issues come to mind that are we missing addressing associated with required precursors to a 2025 human landing?

One thing that I note and have observed in my own field of planetary science for decades is that geologists think there is no life on Mars and therefore we don't need to worry about it. Biologists think the opposite. I see that this same type of thinking is showing up in this discussion.

Christopher McKay's comments:

Briefly describe the science of all instruments you would propose for life detection experiment.

1. Health hazard life detection: An instrument such as SOLID that specifically searches for life with a common biochemistry (immunology) with life on Earth. SOLID (Signs Of Life Detection) uses antibodies stuck on a chip to detect antigens.

2. Martian life detection: An instrument such as a Capillary Electrophoresis Amino Acid chirality system that searches for biomolecules of general use to biology. This instrument works like a GCMS in miniature. The Capillary Electrophoresis does the separation of the Left right hand amino acids due to a chiral packing inside the capillary. Detection is with a fluorescence tag added to the amino acids.

3. Habitability: An instrument such as the Wet Chemistry Laboratory that characterizes the salts in the soil including perchlorate and other oxychlorides. This flew to Mars on Phoenix. Add water to the soil in a tub with ion specific electrodes.

Although we would all like it to be possible to do a precursor life detection experiment, please describe your evaluation of the risks associated with not doing so. Can you imagine life detection experiments only done after human arrival? Clearly doing the science of origins may be harder but probably not impossible.

I don't think the need to do precursors is compelling. Humans can help do these experiments.

Locations with liquid water or recent liquid water have the best prospects of having viable Martian life. Hence, is it not prudent to keep away from those sites deemed to be the best prospects for having extant martian life in the first human mission and allow those investigations to be done later?

Not necessarily. If you are searching for life... go to where the life is likely to be.

What major issues come to mind that are we missing addressing associated with required precursors to a 2025 human landing?

Perchlorate as a health hazard.

Margaret Race's comments:

Briefly describe the science of all instruments you would propose for life detection experiment.

1. Initial science (telerobotics?) to focus on understanding of local environment around base infrastructure -- to ensure that the zone is 'safe' (no life detected) prior to crew outdoor activities--then use robotic-assisted life detection surveys beyond landing area.

Although we would all like it to be possible to do a precursor life detection experiment, please describe your evaluation of the risks associated with not doing so. Can you imagine life detection experiments only done after human arrival? Clearly doing the science of origins may be harder but probably not impossible.

2) (see comments above- with Planetary Protection & Life detection in mind. still hope for Mars Sample Return-- or Phobos/Deimos teleoperated instrument surveys prior to human activities.

Locations with liquid water or recent liquid water have the best prospects of having viable Martian life. Hence, is it not prudent to keep away from those sites deemed to be the best prospects for having extant martian life in the first human mission and allow those investigations to be done later?

3) Again-- precursor robotic surveys and life detection will be essential-- Humans should avoid areas with liquid water. Robotic and sampling equipment MUST be designed with capability for clean /re-cleaning when used in situ for repeated surveys and data gathering. Necessary for both science integrity and crew safety.

What major issues come to mind that are we missing addressing associated with required precursors to a 2025 human landing?

4. Can we realistically accomplish a crewed landing in 2025 without clearer documentation of having a 'safe' landing zone and base- (as discussed in SSB report, 2002 Safe on Mars). Since it is unlikely that a robotic Mars Sample Return mission will occur before a proposed 2025 human landing, what

telerobotic data are of major importance for reviewing proposed landing areas for verification non-life detection?

Charles Cockell's comments:

On the question of whether we should avoid liquid water. Probably based on PP concerns we'll be required to keep away from it. It may be very briny and so it's not obvious it would be useful for first stage human exploration anyway (need to look at the energetics of getting water out of brine versus from the atmosphere or melting permafrost, but I'm guessing the latter may be easier).

On the question of life detection after a human arrival - again these experiments may be required for PP reasons, but it should still be a priority to determine whether there is any life or habitable environments near the landing site.

I'm in agreement with Pascal, we shouldn't get too focused on life detection - I think it's vital to do this, but it is just one element in crew survival along side other experiments. As life detection instrumentation need not be bulky if can be part of the payload.

As stated before, I think an equal priority is chemistry/toxicology of soil for human ingestion.

Andrew Schuerger's comments:

Day 2 feedback on Rosalba Bonaccorsi's comments: "During our 2006 NASA Spaceward Bound expedition in the Atacama Desert we stayed at the desert station in Yungay. Our fecal wastes were gathered in a septic tank and I was running ATP assays to see how much contamination was generated by us around critical areas (shower place, kitchen, common areas, septic tank, etc) vs. areas away from the station. ATP assay tells how much living active microbes you have in the environment. Surprisingly, swabbing dried poop did not yield microbial activity, which means our poop was being sterilized in a few days under the Atacama's sun/ UV radiation. This result can be applied to predict on what could happen on Mars. So, I assume that if the poop is left exposed on the surface of mars, it will be sterilized, providing that the poop itself is not dumped into the aquifer(s) ....hopefully not."

1) ATP assays do not do a good job at detecting inactive and dormant bacterial spores; like in the genus Bacillus.

2) UV irradiation can only achieve biocidal activity on fully exposed spores and cells on the outside surfaces of materials (e.g., on the external surfaces of feces, solar panels, kapton tape, electrical boxes, etc.). Thus, we cannot assume that the UV fluence rates in the Atacama Desert or on Mars will sterilize complex 3-D components, waste products, or equipment. UV only works at the surface of materials.

3) Organic-rich or microbial rich waste products (of any sort) should not be deposited on the surface of Mars. Once released, the contamination (both organic and microbial) can be widely dispersed. Waste will have to be sterilized and/or neutralized within the crew habitats before they are placed in sealed waste bins on the surface.

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Day-3 Questions:

Briefly describe the science (~one sentence) of all instruments you would propose for life detection experiment.

1) GCMS is required to search for organics in the regolith or subsurface samples.

2) A soil chemistry instrument is required to measure the pH, Eh, EC, Redox potential, dissolved ions, biotoxic ions, etc. of the regolith at the sample location. The geochemistry is important to properly interpret the life-detection assays.

3) Fluorescent detection of organics and metabolism could help confirm the other life-detection results.

4) An enhanced (updated) Labeled-Release experiment is still a good approach to look for microbial catabolism of complex organics under Martian conditions.

5) We must think of the "ecology of an extant Mars microbiota" when we design any life detection experiment. The Mars microbes (if present) might not be able to utilize the rich organics typically used to grow terrestrial microorganisms. For example, the Mars microbes might only be able to utilize organics in interplanetary dust particles that accrete annually to the surface.

6) DNA, RNA, ATP, etc. detection systems would also give us insights if an extant microbial community is similar to terrestrial life, and rule out a common heritage of the lineages of life for the two planets.

7) Assays for non-racemic mixtures of organics will inform us if unique types of chirality have been selected by an extant Mars microbiota.

Although we would all like it to be possible to do a precursor life detection experiment, please describe your evaluation of the risks associated with not doing so. Can you imagine life detection experiments only done after human arrival? Clearly doing the science of origins may be harder but probably not impossible.

1) I think it is important that we conduct at least one modern set of life detection experiments on the actual landing site selected for the human missions. We should also include assays using terrestrial prokaryotes (e.g., bacteria and archaea) and eukaryotes (e.g., Tardigrades, fungi) that have been genetically engineered with "suicide genes" to evaluate how terrestrial life reacts to actual Martian regolith/fines/soil/subsurface materials react.

2) Humanity is struggling with an epistemological crisis in designing a human mission without fully understanding what could go wrong on the surface. We do not know how microorganisms (including pathogenesis) from an extant and viable biological community on another planet will interact with human and terrestrial life. We should not just hope that the interaction will be benign, we must test it at least once.

Locations with liquid water or recent liquid water have the best prospects of having viable Martian life. Hence, is it not prudent to keep away from those sites deemed to be the best prospects for having extant martian life in the first human mission and allow those investigations to be done later?

1) Water is not critical for a quick Sprint mission with a surface residence time of a few weeks. But longer missions or a permanent base camp location must have a local source of water to remain viable.

2) Physiochemical processing of waste water will never get 100% of it back into the life support systems. Thus, the habitat will need to be replenished from external sources. The options for external sources are rocket supply ships in place or sent at every launch window, or a local Martian source.

What major issues come to mind that are we missing addressing associated with required precursors to a 2025 human landing?

1) Landing sites with the potential to harvest ice or liquid water for long-term habitation should be a key priority.

2) As a plant pathologist, life detection at the actual landing site is a high priority in mind.

3) Budget! Budgets! And Budgets!

4) If the initial 2025 landings are to create a long-term “basecamp” on Mars, then the use of bioregenerative life support systems (BLSS) research in NASA must be restarted as soon as possible. The only way to reduce the equivalent system mass for long-term human missions is through BLSS approaches. And again as a plant pathologist, we need to have a much firmer grasp on the geochemistry, hydrology, and potential pathological and biological interactions between the Martian surface and terrestrial life before sending humans.

5) I don’t believe we will be successful in completely separating the external and internal environments of a human habitat on Mars. Thus, I expect that there will be unintended contact between humans and the surface. We need to understand how that interaction might develop before sending humans.

<overnight>

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Friday’s Questions and Comments from Thursday:

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Questions for Day 5 (Friday, Aug 26):

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Given a human landing in 2025, please respond with your final/summary comments on what is essential to do in precursor missions to that. Please base this on our discussions and your other thoughts. I continue to encourage us to avoid programmatic and regulatory issues and stay to the constrained technical discussion.

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Panel Summary by Moderator:

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The details of all the comments from ePanelist can be found at the bottom of this email.

I'll present here my overall moderator's perspective on our ePanel and where we have gotten.

What can we say we learned:

I suspect that many on the panel will say these summarized statements have always been obvious, but hopefully even they have had some fleshing out of their perspectives.

We have made good progress on laying out what the ePanel views as essential precursor activities that need to be accomplished in precursor missions leading to human habitability. First and foremost the complexity of the issues at hand in order to be ready to land humans in 2025. This is an area in which the world's space government space agencies should support these audacious commercial endeavors in all ways those agencies can. Human exploration of another planet is a fundamentally human endeavor and the future of all our children will be influenced by them.

Primarily in our discussions we have focused on four important arenas: detection of life on the surface, understanding of surface toxicity to Earth organisms including humans, forward planetary protection and back planetary protection. Sitting on the sidelines of our discussion, but still often on our minds, is the need to choose an appropriate (possibly a single) landing site and understanding how to acquire resources for life - most importantly water.

Detection of life on the Mars surface:

The reason that the detection of life is so important is that life, even if currently dormant, given the right circumstances can flip back into activity, grow and create problems. We know that pathogens introduced to organisms without previous exposure can cause great havoc such as occurred to the Native American population with the introduction of Europeans and their diseases. And it is false to believe that only co-evolving organisms can cause harm. Both viruses and organisms like those of red tides that can deplete oxygen in an ocean region can be very damaging even to species that did not co-evolve in recent times. So if there is life present on Mars, it is important for Mars crews to take additional precautions and it is important to not introduce back contamination to Earth. Unfortunately, Mars life, if it exists, almost certainly won't be homogeneous on the planet and it is expected to vary based on water availability and on having the protection given by being at depth below the surface. Hence, we will need to do an ongoing sequence of detection activities on Mars - both to hone our techniques and operation on Mars but also to do detailed surveys of places where extant life might reside on Mars. In addition, there is no single test that will convincingly indicate life, especially non Earth life if it exists. For each location that we search for life we will need to run multiple tests in order to be a convincing test that life exists there or not. Hence, all of these tests and instruments will be run many times at a multitude of niches on Mars. This will be an ongoing development and deployment process. It could be thought of as analogous to a Silicon Valley product deployment process. It's time to get the first betas out the door.

Detection of toxicity in soil & its mitigation:

We know that there are perchlorates on the surface of Mars and we know it can be toxic to humans. We need to know the salts and other toxic components of the Martian surface materials. Once we know that then we must establish technologies and procedures to mitigate these risk to the human surface crew.

Forward and back contamination planetary protection:

Although human crew safety is a critical priority, as Margaret Race points out below the Planetary Protection policy for human missions indicate that 'Protecting the Earth' is the highest priority goal.

We understand that parts of our microbiota will escape from a crew habitat and we understand some of the processes that might lead to dispersal of those microbes. We anticipate that most, maybe virtually all, of those microbes will be rendered inert by the harsh martian surface conditions. However, in order to minimize human impact on (possible) fragile biological communities on Mars we should measure and introduce countermeasures to the spread of those organisms we have introduced from Earth.

The risk of back contamination of Earth is seemingly of low probability but of unknown consequence if it occurred. Most theories however would argue that this consequence is low and manageable.

The comments by the ePanelists from Day 4 below (and in previous days' postings) does an excellent job of clarifying many of the issues associated with planetary protection related to such a 2025 mission. It will be the job of the ePanel summary report to bring these components together into a coherent story for the possible 2025 human Mars mission and its precursors.

Resources

Access and utilizing Mars resources needed by crewed missions, like water, oxygen and construction materials, will be a delicate dance with planetary protection, crew survivability and our understanding of the aliveness and dangers of the planet. This ePanel has only brushed against those issues but enough so for some of the ePanelists to argue for the advantages of a single initial base for precursor and human landings and to point to the importance of a well thought out strategy of selection of that site. That selection process should initially not be thought of as picking the richest science landing site/base but rather picking a landing site/base which best balances this full set of objectives.

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(Previous) Questions for Day 4 (for Thursday, Aug 25):

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If one could only fly one life detection instrument in the first opportunity (2018) what instrument would that be and why? (Assume other instruments are flown on other opportunities.)

If you had a human crew contributing to the life detection or soil chemistry at some stage during the investigation what would you do differently or what instruments would you use that you haven't been considering? SEM for microbial visualizations?

Since a negative result for extant life detection from a sample return mission gives little information on that issue what is the importance of a sample return mission for our assumed baseline scenario?

During Apollo space suits, astronauts and cabins were inundated with surface materials from the Moon. For Mars we know we will have a raining down of fine materials over time on all exposed objects. Since perchlorates and possibly other Mars surface materials can be harmful what can we do prior to humans landing to better understand how to mitigates these surface hazards?

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Details of ePanel responses for Day 4 (Thursday, Aug 25):

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Carol Stoker's comments:

If one could only fly one life detection instrument in the first opportunity (2018) what instrument would that be and why? (Assume other instruments are flown on other opportunities.)

A: I think that instrument would be SOLID and the reason is that it is the only life detection instrument at high enough TRL to be ready to fly in 2018. Even that would be a huge stretch and would require immediate funding. But it is only capable of detecting the biomolecules we set it up to detect.

A: Perchlorate is a carcinogen and specifically causes thyroid cancer. It can be mitigated by taking enough iodine like in iodized table salt. At least that is what a colleague who studies this tells me.

If you had a human crew contributing to the life detection or soil chemistry at some stage during the investigation what would you do differently or what instruments would you use that you haven't been considering? SEM for microbial visualizations?

A: This is where I think culturing experiments in a variety of environments and media makes sense.

Since a negative result for extant life detection from a sample return mission gives little information on that issue what is the importance of a sample return mission for our assumed baseline scenario?

A: I think the most relevant samples for sample return to search for life would be soil from the near subsurface and ice from the subsurface, if there is ice at the site. Rocks from ancient Mars would be useless.

During Apollo space suits, astronauts and cabins were inundated with surface materials from the Moon. For Mars we know we will have a raining down of fine materials over time on all exposed objects. Since perchlorates and possibly other Mars surface materials can be harmful what can we do prior to humans landing to better understand how to mitigates these surface hazards?

Comment: I want to vigorously argue with the idea that if Astronauts get sick, we just don't return them or we leave them in Earth orbit and that is the way we prevent back contamination of Earth [as others had previously suggested]. The probability that Mars hosts disease agents that humans can catch is vanishingly small as a risk for a variety of reasons. But the probability that martian microbes could hitchhike back to Earth in the human body, or any of the things returned to Earth is very high if there are microbes in the environment that humans encounter or sample. Microbes are just really really small. Furthermore, there is no guarantee that the mission or trip time is long enough for microbes to wake up and start causing a problem. As we see in the area of retroVirus, sometimes it takes years or even decades for infection by retrovirus to produce symptoms. But I am not talking about making humans sick, I am talking about making planet Earth sick. In my view that is the risk that must be evaluated with data not opinions.

Margaret Race's comments:

Similar for soil chemistry what is the suite of instruments that will give us measures of the probability of toxicity? How do we mitigation for perchlorates, etc.? What. if any, proof of concept are necessary of those mitigations for soil/environmental toxicities are best done on Mars before human arrival?

* These soil chemistry questions are important-- the more we know about soil chemistry , the more informed and relevant planetary protection controls and mitigation efforts can be.

If you had a human crew contributing to the life detection or soil chemistry at some stage during the investigation what would you do differently or what instruments would you use that you haven't been considering? SEM for microbial visualizations?

* Whatever instruments or investigations are undertaken, make sure the crew contributes by collecting data via robotic precursors and telerobotics when they go into new/unstudied areas. Essentially no direct human sampling and handling .-- at least until we know more. (this was affirmed by an NRC study of human missions-- Safe on Mars (2002)

*It will be important to minimize interfering with the science measurements-- and to safeguard the crew at the same time.   Whether outside during collection or returning samples to the Mars lab or containment cache-- it will be important to keep crew and samples separated-- perhaps there will also be a need to do telerobotics in glovebox labs on mars if astronauts intend to handle and study the materials prior to Earth return.

Since a negative result for extant life detection from a sample return mission gives little information on that issue what is the importance of a sample return mission for our assumed baseline scenario?

* any samples returned to Earth will tell us about THOSE particular samples... obviously, planetary protection controls to deal with risks are inevitably fraught with uncertainty-- whether about areas locally, regionally, or planet wide.   Consequently, the Space Studies Board (NRC) has repeatedly reaffirmed the need to use a conservative approach to planetary protection-- assume that ET life exists until proven otherwise.   (this must be reflected in the full mission design and implementation).

* On the one hand, having crew study material on Mars contributes valuable data about the prospect of ET life and its characteristics (or even the absence of life) - BUT studying materials on Mars may raise another dilemma-- IF THEY FIND evidence of ET life, what quarantine measures, back contamination controls and policy issues would arise for returning a knowingly exposed crew? if they were exposed, should they remain on Mars?

*{FYI-- the current COSPAR Planetary Protection policy and its principles for human missions indicate that 'Protecting the Earth' is the highest priority goal of PP policy}

During Apollo space suits, astronauts and cabins were inundated with surface materials from the Moon. For Mars we know we will have a raining down of fine materials over time on all exposed objects. Since perchlorates and possibly other Mars surface materials can be harmful what can we do prior to humans landing to better understand how to mitigate these these surface hazards?

* SEE comments above about NRC's long-standing position on the importance of taking a conservative approach. Already, designs of space suits and EVA assets are progressing with a focus on minimizing dusts and their transport between outside and inside. (ex-- one approach-- have suits be designed to remain outside-- and doff/don of suits be be done thru external suit ports or special areas deliberately isolated from living and lab spaces. Additional attention will be paid to decontamination/cleaning/repair methods for materials, suits, etc that will be re-used during the missions. Lots to do.....

Andrew Schuerger's comments:

If one could only fly one life detection instrument in the first opportunity (2018) what instrument would that be and why? (Assume other instruments are flown on other opportunities.)

1) Only 1 instrument…then, I would fly a SOLID-like fluorescent system that could get hits on diverse organics, chirality of organics (if possible), terrestrial-like life forms, and other exotic biosignature molecules.

If you had a human crew contributing to the life detection or soil chemistry at some stage during the investigation what would you do differently or what instruments would you use that you haven't been considering? SEM for microbial visualizations?

1) The sample return community has correctly argued that it would be difficult to send all of the possible life detection instruments on a rover or lander to "fully" characterize an extant Mars microbiota.

But what we are advocating in precursor missions is to send a suite of the best 5-6 ideas (life detection payloads) in order to get at least some data (positive or negative) on what might be present at a human landing site.

2) Doing the assays after arrival will certainly be part of the mission. But it is folly to send the human crews to a new planet with no working hypothesis if they it will be a one-way trip or a round-trip. All humans want to survive. And if the Mars-return spacecraft has the ability to piloted by the astronauts, then the 5 or 6 of them could decide to return to Earth even if the Terran's refuse entry.

3) The best approach is to make a thorough risk assessment of the safety of sending humans to Mars, fill in knowledge gaps with an aggressively funded set of 1-3 precursor mission, and then use that data to refine the design of the human mission architecture.

4) With no precursor data on the landing site, $0-70 billion dollars (or more) might be spent to realize that a simple design flaw that could have been solved with just a little more testing is no jeopardizing the mission and the crew's health. Think about the original Hubble mirror defects as a good example.

Since a negative result for extant life detection from a sample return mission gives little information on that issue what is the importance of a sample return mission for our assumed baseline scenario?

1) Human-tended life detection experiments are certainly going to be part of their mission (see above). That is not the issue. The issue is whether they are allowed to go to Mars not knowing if it is a one-way, round-trip, or disease and death mission profile. We simply must conduct at least one precursor mission to the selected human landing site. Anything less than that is folly.

During Apollo space suits, astronauts and cabins were inundated with surface materials from the Moon. For Mars we know we will have a raining down of fine materials over time on all exposed objects. Since perchlorates and possibly other Mars surface materials can be harmful what can we do prior to humans landing to better understand how to mitigates these surface hazards?

1) The biggest unknowns is how much of the Martian dust and regolith fines will get into the crew quarters. If this is a trace amount, then we are running a human biotoxicity and pathogenesis experiment whether we call it that or not. Dust settling on the outside of the human habitats should not be any issue because there is a higher pressurized habitat leaking gases out into the low-pressure Mars atmosphere. Thus, dust should not "leak" into the Mars habitats. But the dusts and regolith fines will be carried in via operating airlocks of any sort.

More?

1) Any plausible landing site next to dust covered glaciers (if present), subsurface ice lens, subterranean caves, etc. will be ideal for getting liquid water for the habitats. This is a plausible scenario ONLY if there is no life in the ice or water, or we can prove that it can be 100% sterilized by some method. But this idea again begs for a precursor mission to help constrain the problem. If the design team assumes that no life is present in subsurface sites, they will design equipment that may not properly treat the water. Conversely, if there is no extant life in the subsurface water/ice sources but we assume that there is, then the water treatment facility might be over-designed by 10X. We need precursor missions!

Charles Cockell's comments:

With forward contamination we worry about an organism from Earth that finds a not too strong brine and some meteoritic organics finding a good place to grow. With back contamination, native Mars organisms getting to Earth there is the same problem, but with more organics to eat. The problem is that more invasive species might grow in a way that deplete resources or changes habitat for indigenous organisms - there are many examples on earth, although less well documented in the microbial realm.

Remember that any life detection instrument need not be much mass. If they are talking a relatively large lander (say hundreds of kg (or more) for ore and multiple missions then making life detection essential and even sending multiple instruments need not cost much mass against other priorities in human survival and crew operation (although of course in reality people will argue for every gram when it comes down to it).

On top of all that, they (the crew) can get bored (even geologists) by endless vistas of basalt and sediments for several months/years. Mending defunct life support systems as a primary mission objective is not much fun either. Having life detection instruments on previous missions that give them astrobiology objectives on later human missions could even be seen as beneficial for human factors and adding to longer term crew scientific objectives - even the rationale for sending people there in the first place.

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Comments from Friday:

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The summary comments from the ePanelists from Friday are presented near the beginning. (ePaneists closing statements:)

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Comments from the eAudience:

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Joel Hagen's comments:

It makes sense to test for presence of life at the intended human landing site. However, the capacity of dust storms to transport a mix of material from distant locales and near-surface depths complicates confidence in local results.

Can tests include not only detection of life, but detection of recently dead life? I'm thinking of organisms possibly ripped by storms from a sheltered environment and subjected to more lethal conditions while airborne. A massive dust storm could carry a hodgepodge sample of many environments.

Given Carol's point "No life detection experiment with negative results can prove the nonexistence of life on Mars" then perhaps in addition to vigorous life detection strategies, it would make sense to simply design a human landing around the worst (best?)-case assumption that there is life and design in all the forward and backward protections that implies.

In other words, maybe regardless of progress on next-gen life detection, "we" should really figure out how to clean the suits or otherwise prevent the outside of the suit from contacting people or the inside of the lander/habitat. Important perhaps for the perchlorate issues anyway?

Then, what aspect of that can be scaled to a small payload experiment?

Testing seals?

Some method of blowing or rinsing or decontamination?

Some experiment that has as a subtext keeping the outside out and the inside in while interacting with Mars.

Rosalba Bonaccorsi's comments:

I have a few reasons to believe that fecal contamination shall not be a big issue, at least at the beginning...with a small human population on Mars. Here is why.

During our 2006 NASA Spaceward Bound expedition in the Atacama Desert we stayed at the desert station in Yungay. Our fecal wastes were gathered in a septic tank and I was running ATP assays to see how much contamination was generated by us around critical areas (shower place, kitchen, common areas, septic tank, etc) vs. areas away from the station.

ATP assay tells how much living active microbes you have in the environment. Surprisingly, swabbing dried poop did not yield microbial activity, which means our poop was being sterilized in a few days under the Atacama's sun/ UV radiation. This result can be applied to predict on what could happen on Mars.

So, I assume that if the poop is left exposed on the surface of mars, it will be sterilized, providing that the poop itself is not dumped into the aquifer(s) ....hopefully not :)

Bruce Damer's comments:

Searching the Martian rock record for evidence of stromatolites

I have just returned from a month of meetings and field work in Western Australia. Joining an international group of geologists, we extensively explored the Pilbara region with a focus on stromatolite preservation in the 3.5 Ga Dresser Formation. As UNSW's Martin Van Kranendonk and Tara Djokic reported at the 2015 Astrobiology meeting, we observed extensive preservation of various stromatolite microbial community morphologies in several Archaean surface fresh water hot spring outrcrops. As they pointed out, the oldest and best preserved fossil evidence for life on Earth is in these silicified hot spring strata. In fact, all hot spring deposits through Earth history, back to 3.5 Ga, contain evidence for life.

This strongly suggests that a visit to known ancient hot spring localities such as was discovered at Columbia Hills by the Spirit rover or other hot spring outcrops as have been identified by orbital imaging should be the highest priority places to go on a search for evidence of life on Mars, even if it is past life. Dr. Van Kranendonk should be consulted here but my personal observations and sampling of the Australian localities suggest that stromatolite textures might observed through careful close-up imaging of exposed rock surfaces on Mars, especially associated with hydrothermal activity. This assumes a form of life on Mars resembling microbial communities that dominate the fossil record, and life today, on Earth.

Weathering and burying by outflows or sedimentary overcovering argues against other locations such as lake/ocean shores or fluvial environments. Stromatolite textures are virtually never preserved in these environments on Earth. It should also be considered that surface life on Mars might have last been present in hot springs, before conditions changed to prevent microbial communities from being present in sub-aerial environments. Ancient hydrothermal systems might have also preserved sub-surface living communities for far longer than any other locality, providing life forms access to the surface for longer, and a chance for us to detect them.

In May of this year we published a new theory of the origin of life on Earth in the journal Life. It might interest the panel to referenced the following essay which covers the evidene for early life in Australia and the chemical model for an origin of life in fluctuating fresh water pools:

http://www.mdpi.com/2075-1729/6/2/21/htm

Bruce Damer's comments:

SHEPHERD ISRU approach and architecture for human Mars exploration and it may minimize the need for Mars surface developed rocket propellants.

Several years of design work by myself, Peter Jenniskens (SETI) and Julian Nott led to the proposal of the SHEPHERD asteroid encapsulation and gas handling concept as introduced in New Space (March 2015):

http://online.liebertpub.com/doi/abs/10.1089/space.2014.0024

and in a TEDx talk I gave in April 2015:

https://www.youtube.com/watch?v=wLMHcUg36yc

This concept, while notional and requiring years of prototyping and demonstration flights, proposes to capture volatiles from NEOs and bring them to LEO/CisLunar and Mars orbits providing abundant sources of water and other consumables for propulsion and sustaining of crew+vehicle. Such space-based fueling stations would negate the need for atmosphere processing or water ice extraction on Mars, which would be fraught with technical challenges, as telerobotic mining equipment is on Earth today. The TEDx talk presents an alternative architecture in which crews are based in the cleaner and safer environment in Mars orbit and using abundant propellant supplies, make multiple sortie missions to the surface with a smaller lander/buggy package. Such an approach creates a much more sustainable exploration approach with lower launch weight, secured return fuel and consumables, and meets broader science objectives by permitting much longer stays and greater access to surface sites.

Stephen Braham's asked:

It does seem, from what most have said, that we know enough now that a full and complete life check is required on a risk and morality POV. However, the implications of that are very strong, correct?

With regards to that I would really like to know how Margaret and Charles feel about how contamination balanced against resources, and human operations; it seems to me that life detection will need a massive network (in all senses of the word) of measurements that needs to be on a scale GREATER than the future human exploration region, because a human, or even a robotic system that may come into contact, even Nth-hand, with a human (if we just ban the crew from leaving the lander and tele-op) everything. Once you think resources, you can see that a shallow drilling experiment is pretty much useless, because life can be at one depth in one place, and transported up in other places, and especially may be so transported where there are water resources, eh? The inhomogeneity that you would expect seems to be a killer for the usefulness of any smallish 2018 robotic exploration (say less than a few dozen Dragon landed capacities, doing the numbers in my head), but also seems to need something like that for an even semi-safe (to Earth!) landing, unless we truly ban any return over very long timescales. 2025 doesn't seem to be a point where you would emplace landers, comms, etc, for a completely hab-locked colony, eh? And it would need to be hab-locked until massive life detection has been done?