

**Summary of the presentations, discussion, and main outcomes of the 9th MEPAG virtual meeting (VM9)
June 26th, 2020, 2:00-4:00PM EDT**

*Posted agenda and presentation files: <https://mepag.jpl.nasa.gov/meetings.cfm?expand=vm9>
Notes primarily present an overview of discussion, with brief description of and links to presentation materials.*

General MEPAG Announcements

- Please respond to all requests for general or meeting-specific MEPAG feedback via the email MEPAGmeetingQs@jpl.nasa.gov.
- The MEPAG Executive Committee will henceforth be called the Steering Committee, as part of a request from NASA to standardize Analysis Group nomenclature.
- Barbara Cohen stepping down from Steering Committee. We thank her for all of her invaluable contributions. A notice soliciting a replacement will be sent out in July.

Past and On-going MEPAG Activities

- **R. Aileen Yingst**, MEPAG Chair (Planetary Science Institute), presented the agenda for this meeting and an overview of recent MEPAG activities. Slides are available here: https://mepag.jpl.nasa.gov/meeting/2020-06/01_Yingst_Feb2020_MEPAG_VM9.pdf.
 - MEPAG 38th F2F meeting (virtual) was on April 15-17, 2020
 - PAC meeting (virtual) scheduled for Aug. 17-18, 2020
 - AG Chairs held a caucus regarding Decadal Survey issues on June 2, 2020 ([see July newsletter](#))
 - New Decadal Survey White Paper deadlines:
 - Science white papers due July 15
 - Mission concept papers due Aug. 15
 - All others Sept. 15
 - Upcoming workshop on July 2, 2020, 12:30-3:00PM EDT
 - Request for the papers, signatories, and references to be posted on the MEPAG reports site. This info will be added to the forthcoming MEPAG newsletter.

Michael Meyer presented on MEP Status

- Continuing adaptation to COVID-19 with remote work. No changes expected in near future within both MEP and NASA more broadly.
- Introduced new Mars Sample Return Program Director Jeff Gramling.
 - Q: To whom does Jeff report?
 - A: Thomas Zurbuchen
 - Q: Request for summary of Jeff's responsibilities
 - A: Prime responsibility is getting the samples back to Earth. Although there are some things still to be worked out, Mars 2020 remains under the purview of Jim Watzin and the Mars Exploration Program, with MEP expected to take over once the samples arrive on Earth and to handle curation. Details are still being worked.

Bruce Jakosky presented on the Mars Architecture Strategy Working Group (MASWG)'s preliminary results in a talk on “**Mars, the Nearest Habitable World – A Comprehensive Program for Future Mars Exploration.**” Input and feedback on the concepts and discussion are requested to MASWG-Feedback@jpl.nasa.gov, no later than 10 July. Slides are available at <https://mepag.jpl.nasa.gov/meeting/2020-06/MASWG-preliminary-results-MEPAG-26June2020.pdf>.

The material that follows is a best-efforts summary based on the presentation slides, notes taken during the presentation and recordings of the Q & A discussion (including the chat box material). These materials can be viewed in full on the website.

MASWG formed by NASA's Planetary Science Division in response to NAS mid-term Decadal Survey committee recommendation. This is a committee report of findings and recommendations to NASA, not necessarily direction that NASA will implement. The intent is to share the report with the Decadal Survey by means of a white paper.

There is a proposed change to expand from the “follow the water” paradigm to understanding the “nearest habitable world.” The focus on reading the Martian geophysical record of change would address:

- Potential for life
- Mars' habitability and changing climate
- The first billion years of planetary evolution
- Using Mars to understand exoplanet evolution
- Mars as a destination for human exploration

High-level summary of findings

1. Many of the most compelling scientific objectives needed to address planetary (including exoplanet) questions can be most effectively achieved at Mars, and a coherent Mars program is required to make the best progress on those objectives.
2. Two decades of exploring Mars from orbit and on the surface have revealed a currently dynamic planet with a diversity of ancient environments, many with the necessary conditions for habitability and clues to their evolutionary history.
3. For both science and exploration by humans, Mars has the compelling advantages of being the most easily accessible planet by both robotic and human missions and retaining a record of its geological, climate, and perhaps biological history throughout time.
4. Mars Sample Return represents a major step forward, is the key flagship mission for Mars, and should be completed. As currently envisioned, MSR would give us an exquisitely detailed understanding of one carefully chosen place on Mars. Many fundamental science objectives exist that go well beyond what can be accomplished with MSR, providing a systematic look at a dynamic planet.
5. A Mars program can most effectively address the full range of key science objectives by appropriately utilizing missions in all size classes, in addition to MSR. The key is to match the mission class to the science objective.
6. Rapidly evolving small-spacecraft technologies and procedures could address many key science objectives. This class of missions could revolutionize robotic exploration of

Mars. The most critical need is for affordable access to multiple places on the Martian surface with adequate payload/mobility.

7. Purely commercial or commercial-government partnerships for exploring or supporting the exploration of Mars, where the private entity bears a reasonable fraction of the investment risk, are in their formative stages but do not currently exist for Mars. A Mars-focused CLPS-like program could allow technology development for future exploration as well as delivery of science payloads.
8. There is tremendous value in developing collaborations between the many different governments and entities interested in Mars exploration.
9. The scientific and the human explorations of Mars are inextricably intertwined. Addressing science objectives will be an integral part of upcoming human exploration, and preparing for future human exploration provides one of the rationales behind having a vigorous robotic Mars scientific exploration program today.

High-level recommendations

1. Mars Sample Return should proceed as currently planned, as envisioned by *Visions & Voyages*, as it will constitute a major step forward in our understanding of Mars.
2. NASA should support missions that address fundamental science objectives at Mars in addition to MSR, using the full range of technically viable mission classes. During the MSR era, the emphasis should be on achieving other high-priority science objectives, while developing the needed technologies for going forward.
3. To the extent possible, missions and instruments should be openly competed; where specific investigations are desired, objectives can be defined and then opened to competition.
4. For this next phase of Mars exploration, NASA should retain a programmatically distinct Mars Exploration Program. NASA should institute mission or budget lines that can allow Mars-specific missions, from small spacecraft through New Frontiers-class missions, to be strategically integrated into a program, with missions chosen and implemented *as appropriate for the science to be achieved*.
5. A robust Mars exploration program will require affordable access to multiple places on the Martian surface and affordable long-lived orbiters. NASA should invest early to expedite the rapidly evolving small spacecraft technologies and procedures to achieve these capabilities at lower costs than past missions.

Recommendations for a Successful Future Mars Exploration Program

1. The guiding principles required to drive the program should include:
 - Be responsive to discoveries by ongoing and new missions;
 - Address science priorities as defined by the Decadal Survey and by MEPAG;
 - Have missions build on each other both scientifically and technologically;
 - Compete missions or payload elements to the extent possible within strategic direction;
 - Inject a sufficient number of flight opportunities to sustain technical capability and to achieve steady progress on key goals; frequent missions may be essential to attracting the commercial sector and international partners;
 - The choice of mission class should be determined by the specific science objectives.

2. Program should be sustained at a steady funding level, with commensurate results. The size and scope of the program — and therefore the progress that it can make — will depend upon the resources provided.
3. Develop a line of PI-led small spacecraft, Discovery and New Frontiers-class missions, competed in a separate program line while addressing strategic goals.
4. The Program should have a protected, adequately funded, and competed technology development program to advance instrumentation and developments in key areas (e.g., as is being done for the Mars Ascent Vehicle). The technology invested should be focused and leveraged within NASA and with other agency and international and commercial entities.
5. NASA should develop low-cost approaches for entry vehicles at all size classes, including entry, descent, and landing; for long-lived orbiting spacecraft; and for aerial vehicles, landers, and rovers to provide access and mobility after landing.
6. NASA and the Mars community should study the feasibility of adapting the CLPS program to Mars. A successful Mars-focused Commercial Mars Payload Services (CoMPS) could serve as a programmatic vehicle to allow, at reduced cost, development of technologies for future exploration as well as delivery of science payloads.
7. NASA and the Mars community should continue to explore, negotiate, and support international collaborations as a means of leveraging flight opportunities to achieve compelling science.
 - Involve the respective scientific communities in the definition and execution of joint missions
 - To the extent possible, compete missions and instruments to get the best science
 - Financially support the mission participants adequately to achieve the mission objectives (Instrument Teams, Science Team members, Participating Scientists, Interdisciplinary Scientists).
8. Adequately fund the analysis of returned mission data so results can be achieved in timely fashion; support extended missions as long as they make solid scientific progress.
9. Enhance interactions between the revitalized Mars Exploration Program and the Human Exploration & Operations Mission Directorate (HEOMD) to define needs and the opportunities to address them. This group would ensure that:
 - Adequate, accurate, and appropriate information and experience is provided in support of human missions
 - Scientific progress is sustained and advanced by missions with humans

To demonstrate how a Mars Exploration Program could pursue compelling science objectives while utilizing a suite of missions, four “mission arcs” or scenarios were defined; they are examples and do not encompass the entire range of compelling options.

Q&A

Q: Under "Why Does Mars Need a Program?" should that rationale be incorporated into the upcoming Decadal Survey activity as a ground-rule, or something to be studied by them?

A [Jakosky]: This study is to some degree independent, but can be used as an input.

Q: What is the definition of "small spacecraft"? Is it sub-discovery class?

A [Jakosky]: "Small spacecraft" is defined as having life-cycle costs (including launch vehicle and Phase E ops/science) in the range of \$100-\$300 million.

A [chat discussions]: The community is working to define this. It has been suggested to use a 200 kg upper limit [Fraeman] or 180 kg limit (<180kg)

(https://www.nasa.gov/directorates/spacetech/small_spacecraft/smallsat_overview.html) [Spry], or that it can be ESPA/rideshare [Grimm]. [Edwards] suggests that cost, not mass, should be the primary consideration in defining "small" mission concepts. The "breakpoints" of cost vs mass will evolve with technology, LV capability, mission concept (orbiter vs lander), etc.

Q: Would a Phoenix-sized and capable mission but built as Class D be a "small spacecraft"?

A [Cohen]: I don't think you can retroactively apply Class D to an existing design. I am pretty sure a Class D Phoenix/InSight will break [the cost limits]. From experience. Different architecture is necessary.

Q: What are the "needed technologies" other than propulsion and comm for small sats?

A [Jakosky]: We discussed EDL and scientific instruments, but did not create a list of specific technologies.

Q: About recommendation #5: "A robust Mars exploration program will require affordable access to multiple places on the Martian surface... NASA should invest early to expedite the rapidly evolving small space technologies and procedures to achieve these capabilities at lower cost..." You mentioned "entry to the surface" is included here, does this mean specific investments in EDL technologies?

A [Jakosky]: Absolutely. Getting down to the surface at a cost affordable for small sats/Discovery class has to be a high priority.

Q: Mars is an attractive target for multiple space agencies these days: NASA, ESA, the Chinese, ISRO, UAE, ... Over the next decade there should be multiple opportunities to fly NASA investigations as Missions of Opportunity hosted on non-NASA platforms. Did the MASWG consider MoOs as an element of the Mars program going forward?

A [Jakosky]: Not explicitly. It is too difficult at this stage to identify a set dollar amount or specific opportunities.

Q: Remember that the lunar CLPS model is NASA buying payload space on missions that are going anyway. Is there a similar provider-based market for Mars yet? Or would NASA be the sole customer?

A [Jakosky]: The capability has not been demonstrated yet, so it's been a bit premature. It's a completely open area, and ripe for NASA to push and develop something.

Q: Any recommendation about R&A changes/ enhancements to better support a Mars program?

A [Jakosky]: Strongly support data analysis through phase E for missions, but did not specifically comment on the R&A program.

Q: Does investment in communications include orbital relay for small sats?

A [Jakosky]: The community will have to decide this. There is clear need for tech demo program, but at this time MASWG is not prepared to do it.

Q: Some objectives can be accomplished partly with a SSc, better with a discovery class, and much better with a NF class. How was this handled/envisioned?

A [Jakosky]: MASWG did not go into this level of detail; it would need to be further assessed by the community.

Q: So, are we assuming there will be a launch every opportunity that we can attach onto that is compatible with getting a small spacecraft to Mars? Will the small spacecraft have propulsion capability to get it to Mars no matter where it's ride is going?

A [Jakosky]: For one or two arcs, that would be more than one per opportunity. Having fewer than that, it would be less of a program and more of a series of separate missions.

Q: This may not be appropriate for Bruce to address, but JPL's recent merger of the Mars Exploration Directorate and the Solar System Exploration Directorate into the Planetary Exploration Directorate (name?) is contrary to the MASWG recommendations. Can anyone comment on rationale for this change?

A [Zurek]: There is still a MEP that is led at HQ and a program office at JPL. Institutionally, it has been shifted from the Mars directorate to a combined directorate, but that alone does not change the emphasis of the program and NASA-sponsored activity.

Q [Cohen]: In Slide 25, in situ geochronology is given as an example in "small spacecraft" but in slide 27 it is colored dark blue for Flagship. Our PMCS conclusions were that robust, dual-chronometer in situ geochronology for Mars can be done in NF-class missions and single chronometer instruments could be flown in Discovery. Happy to talk more.

A [Jakosky]: will have discussion offline

Q: How do you see the mentioned phases for the different scenarios spread over the next decade?

A [Jakosky]: Likely can't start developing all 4 arcs simultaneously, but should start as soon as possible.

Q: Do you have a sense of how one of these arcs would be selected? (Or a new one proposed?) They are all great, but I would suspect it's easier to propose a program that has a clear specific focus, rather than try to encompass all of Mars science. (Analogous to follow the water/life very clear focus of the 2000s)

A [Jakosky]: "Follow the water" was very diverse and seen as a common thread and not very limiting. Mars as the "next habitable planet" is similarly not limiting. Unclear what other arcs we would follow or how they would arise, but it should be open to community discussion/debate and/or to the decadal survey process.

Q: A number of planned white papers are in complete agreement with the MASWG recommendations. Do these recommendations eliminate the need for these white papers, or enhance the need for such white papers?

A [Jakosky]: No, we strongly encourage and underscore white papers. They will in detail inform the decadal survey.

[Yingst] agrees and emphasizes the importance and need for both general overarching ideas like discussed today and more detailed specifics from white papers to inform more specific decisions by the decadal survey.

Q: When talking about habitability, do you also include modern habitability?

A [Jakosky]: I would include it in arcs 1 & 2. Habitability is very broad – ancient exposed, or modern.

Q: Do I read it correctly that only Arc 4 explicitly addresses human exploration goals?

A [Jakosky]: Not at all. For example, the ice investigations in arc 3 are directly tied to human exploration.

Q: How many MSR Missions will be planned for the next 20 years?

A [Jakosky]: Did not get into that, because in the timeframe examined, there is going to be one. A second would depend upon the successes and lessons learned from the first.

Q: With respect to questions of habitability and the potential for life, many would argue that locations like Enceladus, Europa, & other ocean worlds, provide a more attractive location for discovering life and clearly habitable environments. What is the key message the Mars community should communicate that illustrates why an expanding Mars program (perhaps at the expense of an Ocean Worlds program) is the best way to go to answer these questions, since HQ funding isn't unlimited...

A [Jakosky]: All of these objects appear to meet the requirements. Our Mars experience is that these are not easy questions to answer, and you need to understand the planet in detail. It's going to be a lot harder for other bodies due to the lack of prior experience and knowledge, and Mars is closer and more easily accessible.

[Yingst]: Aside from Earth, Mars may be the most likely place in the solar system for the conditions to have existed for an origin of life event, which is a different metric from whether a planet could be habitable. It doesn't negate the search for life elsewhere, but it's important to remember that pretty much all the environments on early Earth were realized on early Mars, suggesting that Mars is in a distinctive position as an extraterrestrial planet where habitability coexisted with the potential for life to arise. That makes it an attractive target.

Q: Did the committee consider any mission or instrument concepts that fit within multiple arcs?

A [Jakosky]: We didn't look for them specifically, but there certainly are some. An ice mapper is one such example.

Q: Will we have an opportunity to provide feedback on the report?

A [Jakosky]: That's why we're here today, to ask for feedback and input. Feedback can be sent to MASWG-Feedback@jpl.nasa.gov by July 10th.

Q: How does a mission strategy support the need for orbital assets for remote sensing with a shift to the search for specific types of targets on the surface for human resources, and science studies, not to mention comms.

A [Jakosky]: I focused on orbital + in situ and soon sample return. Each requires the other to meet objectives. Orbital is a necessary prelude in most arcs to doing investigations on the surface.

Q: Martian meteorites amount to about a fifth of a metric ton of Mars samples, and they have a very long history of providing a critical ground-truth dataset for all landed and orbital research. Is there a place in this program specifically for Mars meteorite research?

A [Jakosky]: I see high value obviously in continuing that analysis, but we did not look specifically at it in the context of this [flight] program, but it is necessary in the broader context of Mars research and the planetary program.

The meeting concluded with a teaser for a presentation on the NASEM planetary protection report reconciling and combining the issues raised in the earlier NAS and Stern reports, likely to be covered in the next (virtual) meeting!