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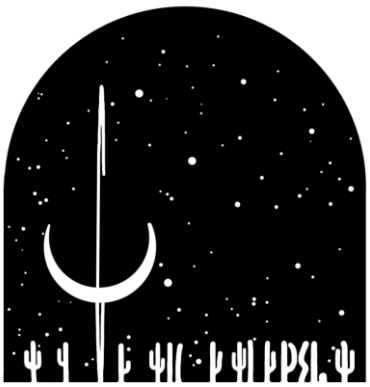

Founded 1972

R. Aileen Yingst
Senior Scientist

10 Julias Way
Brunswick, ME 04011

Cell: (920) 360-3627
PSI HQ: (520) 622-6300
yingst@psi.edu

11 May 2020

Dr. Anne Verbiscer
Chair, Planetary Science Advisory Council
Department of Astronomy
PO Box 400325
University of Virginia
Charlottesville, VA 22904-4325

Dear Dr. Verbiscer,

With this letter I am pleased to report on the 38th major (formerly face-to-face) meeting of the Mars Exploration Program Analysis Group (MEPAG), held virtually April 15-17, 2020. Approximately 180-250 individuals were in attendance online at any given time during the 3 days. This meeting included:

- Updates from NASA Headquarters and the Mars Exploration Program (MEP);
- Status and discussions regarding progress in developing the joint NASA-ESA Mars Sample Return (MSR) campaign architecture, including the next two flight missions (Sample Return Lander with Mars Ascent Vehicle and Fetch Rover; and Earth Return Orbiter with Earth Entry System), as well as international preparations for analysis once samples are delivered to Earth; see Findings #1-2,
- MEP plans for study of a new Mars Ice Mapper mission concept focused on finding very shallow subsurface ice as an in-situ resource for utilization by humans on Mars; see Finding #3.
- Status of ongoing and upcoming national and international spacecraft missions; see Finding #7.
    - ExoMars Rover/Surface Platform launch delayed until 2022
    - JAXA Mars Moons Exploration (MMX with Phobos sample return) approved for launch in 2024. (MMX is now in Phase B.)
    - Mars 2020 and U. A. E. Hope Mars missions going forward for launch in July
    - Status and budget issues for continuing missions ODY, MSL, MRO, MAVEN

- Status of the Mars Architecture Strategy Working Group (MASWG).
- Presentation on final updates to the MEPAG Goals document; and
- Preparations for the next Decadal Survey, including ~35 white papers presented as lightning talks and 3 Mars-relevant Planetary Mission Concept Studies (PMCS) presentations.

A summary of the meeting and associated presentations can be accessed on the MEPAG website here: https://mepag.jpl.nasa.gov/meetings.cfm?expand=m38.

The primary output of the meeting was a list of Findings (listed below), discussed and agreed upon by the community. They cover aspects of Mars Sample Return (MSR), executing Mars program priorities beyond MSR, extended mission funding, Research and Analysis (R&A), international collaborations, small spacecraft opportunities, and preparations for the next Decadal Survey. Included in these Findings are suggestions and requests from MEPAG that were considered important to communicate to the PAC. MEPAG would be happy to provide additional details and/or discussion on these issues as needed.

Thank you so much for your attention, and for the work you and the PAC do in support of planetary science in general, and the MEPAG community in particular.

Sincerely,

Dr. R. Aileen Yingst
MEPAG Chair

Distribution:

Dr. James Green, *NASA Chief Scientist*
Dr. Lori Glaze, *NASA Director, Planetary Sciences Division*
Mr. James Watzin. *Director, NASA Mars Exploration Program*
Dr. Michael Meyer, *Lead Scientist, NASA Mars Exploration Program*

Findings from MEPAG Meeting #38
Virtual Meeting
April 15-17, 2020

Format: The findings for the 38th face-to-face MEPAG meeting are given here, divided into two sections. The first section describes new findings or major updates on previous findings. The second section repeats the suggested actions on all the findings from the 37th MEPAG meeting (held July 26, 2019); those findings are referenced as in #37-n, where n is the finding number from that meeting.

I. New Findings or Major Updates

1. **Finding:** Mars Sample Return, with its goal of providing a scientifically credible cache of samples for return to Earth, was noted by the last Decadal Survey as the highest priority for flagship missions in the decade 2013-2022. The systems engineering progress by NASA in implementing the next steps in Mars Sample Return, communicated for the first time to MEPAG at this meeting, has been comprehensive and significant. Furthermore, the assignment of roles and responsibilities between NASA and ESA in their partnership for the flight elements appeared robust and a high level of commitment and cooperation was evident. Although not as advanced (as expected at this stage), planning for procedures and protocols for analysis of the returned samples was in progress.
    - Relation to prior findings: The new and visible activity indicates major progress on Finding #37-1.

    MEPAG commends the exemplary technical progress in the formulation of the next MSR campaign flight missions and is encouraged by the funding in the President's Budget to start detailed design and implementation of them. The MSR campaign plans and the NASA-ESA partnership are solid, long-awaited steps needed to make a major advance in our understanding of Mars and of solar system processes.

2. **Finding:** The Mars Sample Return campaign is designed to bring carefully characterized, drilled, and sealed samples of sedimentary and igneous rocks from Mars to Earth for scientific study. This return of material from a potential abode of life requires that serious attention be given to both forward and backward Planetary Protection concerns. Presentations were given to MEPAG both with regard to the containment procedures within the MSR campaign (the crucial steps happening in the Earth Return Orbiter payload) and with regard to NASA's overall approach to developing appropriate PP procedures and policy.
    - Relation to prior findings: MEPAG Findings #37-2.

    MEPAG commends the efforts by NASA to update the Planetary Protection procedures and documents (many now in review). MEPAG also commends the involvement of a wide diversity of experts from academics, commercial entities,

and other government agencies in the process, particularly with regard to backward planetary protection. The proposal to formalize this process as it relates to MSR through a board to address sterilization and molecular deactivation issues is a positive next step.

3. **Finding:** The Moon-to-Mars (M2M) campaign has tasked the Mars Exploration Program (MEP) to help with the implementation of an orbiter mission (hereinafter referred to as *Mars Ice Mapper*) to map water ice in the shallow subsurface of Mars as a potential *resource* for humans exploring on Mars. It could also help replenish orbital relay assets later in this decade. The concept envisions an international effort that is still in development, but including possible flight of an L-Band synthetic aperture radar (SAR) built by the Canadian Space Agency. A 2026 launch is envisioned.
    - Relation to prior findings: None.

    MEPAG is concerned that the process by which the Mars Ice Mapper mission appeared in the Mars mission portfolio, its scope, and the plans for its funding were unclear. MEPAG encourages greater transparency and community involvement in the formulation of this concept, in keeping with recommendations by MEPAG-sponsored science analysis groups and the Visons and Voyages document. Consequently, MEPAG recommends that PSD/MEP form a Mission Design Team (MDT), including scientists from the participating international partners and from HEO, to review the M2M campaign requirements and to define appropriate instrumentation for the ice-as-a-resource mapper. To address the ice science objectives formulated by MEPAG through its science analysis groups (e.g., Ice and Climate Evolution Science Analysis Group [ICE-SAG], 2019) would require additional measurements (beyond the proposed SAR). The MDT could consider what additional instrumentation would be needed to realistically address the remaining ice science objectives. Should such objectives be included, MEPAG would recommend that the instruments to meet those objectives be competed.

4. **Finding:** MEPAG notes a disconnect between Senior Review funding recommendations for highly-rated extended missions, and the budget profile for FY 21.

    (1) The close-out of Odyssey (ODY) in early FY21 has both programmatic and scientific impacts. With only $1M in FY21, ODY must start close-out procedures soon in this FY. The removal of a highly reliable working relay orbiter, especially one in a sun-fixed orbit (MAVEN and TGO are not), will limit data return from surface assets (ODY returns 62% of the InSight data), just as other high-band-width spacecraft arrive (M2020 in 2021 and ExoMars in 2023).
    (2) The ~20% decrease in FY21 for MSL (which adds up to a 30% cut over FY20-21) has resulted in no new Participating Scientist call this year and will result in loss of planning days (reduced to 10 shifts/month) and mission efficiency in the investigations of the clay-bearing / sulfate boundary, the exploration of

which was an original reason for selecting Gale Crater as a site for Curiosity. Ending MSL in FY22, while it still has power to rove and explore, would prevent full characterization of the sulfate region and its boundary, which record a key climate transition ("wet" to "dry"?).

(3) The ~10% decrease in FY21 for MRO funding reduces science funding by 20%, bringing the mission to its science floor. While the reductions for MAVEN science are less severe, it will hit its science floor in FY25, allowing for no science as we approach solar max.

The science plans of these extended missions, based on funding at or above FY20 values, were judged to be Excellent/Very Good within the last Senior Review; several received recommendations for increased funding.

• Relation to prior findings: MEPAG Finding #37-5.

MEPAG finds that the substantial reduction of funding for the extended missions MSL, ODY, MRO, and MAVEN and the projected close-out of MSL in 2022 and ODY in 2021 does not reflect community priorities, and is inconsistent with these missions' high rankings by the Planetary Mission Senior Review. The proposed reduction would result in major, perhaps unrecoverable, losses for science, especially in terms of long-term activities upon which numerous science and mission planning activities have come to rely.

5. **Finding:** The communication infrastructure necessary to support ongoing orbital science and rover data return is aging but continues to provide crucial science data utilized to predict or mitigate risk to landed assets from dynamic phenomena such as dust storms. The relay burden will only increase given the arrival of missions to be launched in the next decade. Shutting down a working relay/science orbiter (Odyssey) is an action that increases, rather than decreases, concern about the robustness of the communication infrastructure at Mars. A new orbiter such as Ice Mapper in the late 2020s could provide capability, but does not respond to the need for a systematic approach, for support of InSight and MSL now, and for M2020 and ExoMars RSP arriving in 2021 and 2023.
    - Relation to prior findings: MEPAG Finding #37-3.

    MEPAG encourages a systematic approach to supporting Mars relay requirements both in the near-term for upcoming missions, and in the longer term (a move that could dramatically enable highly productive Mars small satellite concepts). MEPAG recommends that this approach should avoid loss of current relay capabilities which will impact adversely the science of both the relay orbiter and the surface assets.

6. **Finding:** The Administration's FY21 budget contains an increase in support for Research and Analysis (R&A). R&A is crucial in realizing the benefits of missions, and in transferring the benefits of robotic missions to human exploration efforts.
    - Relation to prior findings: MEPAG Finding #37-2.1.

MEPAG is encouraged by the augmentation of the R&A budget for all planetary science (not just Mars), an action that enables flight missions to provide increased benefit to scientific knowledge, inform other NASA programs such as HEO, and increase the robustness of the next generation of scientists who will sustain NASA programs into the future.

7. **Finding:** MEPAG continues to express its enthusiasm about the many international missions slated to launch their first Mars-related missions (e.g., UAE Hope; Japan's MMX) and also applauds the progress by the ongoing NASA and ESA Mars missions including InSight and Trace Gas Orbiter. We congratulate all those involved in advancing these missions, and applaud and continue to encourage the deep cooperation across nations and organizations evidenced in these missions.
    - Relation to prior findings: MEPAG Finding #37-4.

    MEPAG enthusiastically supports the heroic work of ongoing and future missions, in supporting current operations and trying to get spacecraft to launch in extremely difficult circumstances associated with the COVID-19 pandemic. Additionally, MEPAG notes that Participating Scientist programs increase the science return of missions, both by broadening the expertise from which the mission can draw, and by expanding the demographic of mission participation. Where possible and appropriate, MEPAG encourages NASA to leverage international missions and increase international collaboration by supporting Participating Scientist or Guest Scientist programs to these missions.

II. Progress or Updates on Prior MEPAG Meeting Findings
(*The actions suggested by MEPAG on those Findings are in italics.)*

Finding #37-1: Mars Sample Return remains the highest priority science goal for the Mars Exploration Program, as described in Visions & Voyages (V&V) and as recently endorsed in Visions into Voyages (ViV), the NASEM Midterm report. At the 36th MEPAG Meeting, MEPAG encouraged the Mars Exploration Program (MEP) to maintain the goal of completing lean, science-driven Mars Sample Return in the next decade**.** NASA is openly and enthusiastically making major progress on planning for Mars Sample Return (MSR), thereby addressing the Decadal Survey's top priority for NASA flagship missions. The definition of a joint ESA-NASA partnership, including the definition of technical responsibilities, is very responsive to the last Decadal Survey's (V&V) call for international partnerships to result in a robust plan and reasonable cost for the next steps in returning samples from Mars to Earth.

MEPAG is greatly encouraged by the current progress and stands ready to assist NASA in leveraging these developments to result in the next flight missions needed to implement MSR. This includes providing support for science analysis activities needed before samples arrive on Earth (e.g., sterilization protocols, sample handling procedures, sample context analysis, release policy).

- Progress or updates: There has been major progress on MSR, as noted in MEPAG 38 Finding #1, with the approaching launch of Perseverance and the

inclusion in the President's budget of the next flight elements that are needed to retrieve and return the samples cached by Perseverance to Earth.

Finding #37-2: As noted in the Decadal Survey and outlined in the MEPAG Goals, the Mars Exploration Program has additional important priorities along with MSR. For example, a recent MEPAG Science Analysis Group report noted the compelling science questions about ice and volatile evolution in the recent geological past (ICE-SAG). ViV noted that major new science questions have emerged since V&V that will not be addressed by MSR, including diversity of ancient habitable environments, Amazonian climate change, and the dynamic nature of present-day Mars. In light of the first-order discoveries that generated these new questions, MEPAG notes the need for identified opportunities for non-MSR flight investigations (orbital or landed). MEPAG is also intrigued by innovative paths to conduct science at Mars that may be possible through commercial partners and smaller missions. Looking forward, MEPAG believes that the MEP should encompass addressing outstanding questions and priorities in Mars science in parallel or beyond the orbiter and rover missions required for sample return.

2.1 MEPAG agrees with the mid-term assessment that NASA should develop a comprehensive MEP architecture that addresses the Decadal Survey science goals, and is encouraged that NASA is creating a MEP strategic architecture panel for this purpose. MEPAG stands ready to assist in this effort, including vetting of drafts. In parallel with and after MSR, MEPAG also encourages the consideration of MEP missions in all classes, and funding to support research and analysis of the incredible wealth of data acquired from Mars.

2.2 MEPAG recognizes the combination of limited funding and balancing of priorities that limits the designation of identified missions. MEPAG continues to see possibilities in specific, near-term opportunities for small spacecraft missions and secondary payloads, and commends and encourages NASA's activities in this area. MEPAG also encourages development of missions by NASA in partnership with the commercial sector and/or international partners to address high priority planetary science goals in the Mars system during the era of MSR and afterward.

- Progress or updates: The Mars Architecture Strategy Working Group (MASWG) has been making progress towards a report to the community, although that progress has been slowed by the pandemic restrictions on in-person meetings. MEPAG is encouraged by the work of this group and stands ready to assist as needed (e.g., vetting of drafts, providing a forum for community reporting and discussion).

Finding #37-3: The communication infrastructure necessary to support ongoing orbital science and rover data return is aging (i.e., Odyssey is 18 years in flight, MRO 14 years). MEPAG is encouraged that the MEP has been working to extend the life expectancy of the orbital fleet at Mars, mitigating issues as they arise and adding newer capabilities to the relay network (specifically MAVEN and TGO). Further, the current fleet continues to provide crucial science data utilized to predict or mitigate risk to landed assets from dynamic phenomena such as dust storms. However, issues remain, as the relay burden will only increase given the arrival of Mars 2020 and the other ambitious missions to be

launched that in the next decade. While the MSR Earth Return Orbiter can support the MSR Sample Retrieval Lander, it will leave Mars orbit once it has captured the orbiting sample cache, potentially leaving no telecommunications and reconnaissance structure at Mars.

MEPAG recommends NASA pursue innovative ways to refresh the orbital relay and reconnaissance capacity at Mars to support ongoing (e.g., Mars 2020) and new landed science and enabling both orbital and landed science. This may well be enabling for the future use of small spacecraft and competed missions (e.g., InSight) to study Mars. This should be considered by the MEP strategic architecture panel.

- Progress or updates: As noted in MEPAG 38 Finding #5, shutting down a working relay/science orbiter (Odyssey) is an action that increases concern about the robustness of the communication infrastructure at Mars. A new orbiter in the latter half of the decade (Ice Mapper?) might provide capability, especially following the departure of the Earth Return Orbiter with the MSR samples, but does not respond to the need for a systematic approach, especially in the near-term, for support for InSight and MSL now and for M2020 and ExoMars RSP arriving in 2021 and 2023.

Finding #37-4: MEPAG is impressed by the progress of missions in development for 2020 and the early part of the next decade. Many of these are international missions which promise major returns on fundamental science questions, such as the nature of the subsurface, origins of the Mars moons, and full diurnal coverage of atmospheric phenomena.

MEPAG celebrates the many international missions slated to launch and also applauds the progress by the ongoing NASA and ESA Mars Missions and the recently arrived InSight and Trace Gas Orbiter. We congratulate all those involved in advancing these missions, and applaud and continue to encourage the deep cooperation across nations and organizations evidenced in these missions.

- Progress or updates: See MEPAG 38 Finding #7.

Finding #37-5: The recommendations in the National Academy of Sciences report on Extended Missions included funding extended missions at roughly constant levels, including adjustments for inflation, as noted in MEPAG Finding #36-4. Since that time, 1) the development cost over-runs of the Mars 2020 rover, as that mission pushes toward launch, have necessitated cuts in many areas including, but not limited to, the ongoing extended Mars missions. 2) Additionally, the FACA-compliant Senior Review process which judged 3-year continuing mission proposals in 2019 remains unfinished. Its budget guidelines have been superseded by year-by-year budget mandates which continue the earlier practice of decreasing budgets with time.

5.1 While MEPAG laments the loss/deferment of science due to cost overruns, we recognize the budget realities and believe it is essential to get Mars 2020 launched without delay.

5.2 The 2019 Senior Review process, whose budget guidelines were more consistent with the NAS report on extended missions, was unable to provide timely input on extended mission priorities into the budget process. MEPAG

encourages PSD to examine the Senior Review process and make any possible changes that in the future would allow its results to inform programmatic decisions.

- Progress or updates: The current budgets given to missions appear to be inconsistent with Senior Review results (See MEPAG 38 Finding #4). Despite "Excellent/Very Good" ratings, the continuing missions are slated to have:
  - ODY: $1M to finish close-out in FY21; orderly close-out has to start this FY, including loss of relay
  - MSL: Budget reduction of several $M, leading to fewer planning sols and jeopardizing characterization of sulfate zone
  - MRO & MAVEN: Budget reductions imperil proposed science.