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Dr. James Garvin, Lead Scientist for the Moon and Mars
NASA Headquarters
Washington, DC 20546

Dear Jim,

On behalf of its executive committee, I am reporting to you on the meeting of the Mars Exploration Program Analysis Group (MEPAG) that was held near JPL on 30 June - 2 July, 2004. Despite the schedule conflicts and proximity to a national holiday, we estimate that more than 150 people participated in the meeting. As anticipated, we had substantial "drop in" attendance from members of the MER science and operations team, from members of the Cassini science team who were at JPL for the Saturn Orbit Insertion on the 30th, and from international partners, some of whom were at JPL for Cassini-related activities.

The major objectives of this MEPAG meeting were:

- Develop a common understanding of the current status of the Mars exploration (on an international basis), its relationship to other NASA programs, and NASA's current needs for program analysis by the community.

- Discuss the second edition of the MEPAG "Goals and Objectives" document and whether there is a need for revisions.

- Discuss status and results from ongoing/previous MEPAG analysis teams, and launch a new set of analysis teams on key issues for the program.

- Give the community a forum for raising questions, issues, concerns, and compliments.

(Note that, although the MSL mission was of intense interest at this meeting, it was not a topic of discussion at this meeting due to the imminent deadline on the open AO soliciting instruments. Participants were very careful to respect the need to not discuss MSL and, in fact, there was no discussion of MSL beyond publicly available information.)

**The NASA 2011 missions**

Based on the presentations that we have seen, there has been considerable ambiguity so far in defining the 2011 missions, which at this time appear to include two Scout missions and a separate human-precursor testbed mission. Concerns were expressed over the as-yet-uncertain nature of the latter, over the ability to successfully design, build, and launch three separate spacecraft for a single launch opportunity, and over whether adequate funding would be available to support three

missions without inappropriately squeezing each mission to the detriment of their science. MEPAG would appreciate receiving clarification on these points.

Additional concerns were raised over the uncertain nature of the testbed mission. At the request of NASA HQ, MEPAG has convened a two-pronged Human Precursor Mission Science Steering Group in order to provide science input in this area. The two foci of the SSG involve both the measurements that would be made by such a mission and the identification of technology and infrastructure that, together, would reduce risk and cost in a later human mission. This SSG is just in the process of forming, and we don't expect results to be available until later in this calendar year.

A different issue that was raised with regard to the 2011 Scouts involves, in essence, the "ground rules" behind such missions. The Mars Scout Program was originally conceived at least in part as an opportunity for the community to identify and address high-priority science areas that were not a part of the core science program as it is currently being implemented. Examples of such science areas might include obtaining an understanding of the major components of the circulation of the atmosphere, deploying a network of geophysical stations to explore the martian interior, or examining the nature of the upper atmosphere and its interactions with the sun and the solar wind. This concept is widely viewed in the science community as the most appropriate ways for the Scout program to operate. This would be in contrast, for example, to a program in which goals were identified ahead of time and proposals solicited that would be aimed at those specific missions (as with the New Frontiers program, for instance), or in which missions that were aligned scientifically with the goals of the core program might be given preference in selection. We encourage NASA HQ to ensure that the Scout program be operated with the visibility and clarity that we have come to expect, and to let individuals in the community compete openly in the marketplace of ideas (via formation of science teams under the direction of an individual Principal Investigator). We note that the issue of Scout goals could be complicated by the existence of the Exploration Initiative and by the role it might or might not play in the Scout missions.

**The NASA 2013 mission**

There was some ambiguity in the presentations made by the program offices as to whether a decision had already been made to fly a Mars sample return (MSR) mission in 2013. The relative scientific merits of an MSR, followed by sample analysis back here on Earth, compared to the *in situ* investigation by, for example, an Astrobiology Field Laboratory (AFL) have not been addressed in light of recent discoveries from the Mars Exploration Rovers and Mars Express and the current state of technological readiness. As such, a decision on which mission to fly in 2013 is premature from MEPAG's science perspective. The first-order science definition of an AFL has just been completed (by a MEPAG science steering group), and an MSR SSG is being convened in order to address the science issues. The MSR SSG is just now being formed, and we are in the process of developing the charter for it. We anticipate that the input from these groups, in particular taken into account by the upcoming Mars Science Program Synthesis Group (MSPSG II), will play a central role in defining what the 2013 mission will be. We note, however, that it is imperative that, even without a decision today as to which mission will fly, adequate advance planning and technology development be carried out in both areas in order to allow a real choice to be made at a future date.

If an MSR is to fly in 2013, there is a concern that the mission would be designed in order to satisfy the legitimate needs of the human exploration preparation rather than to maximize the science return. These two different objectives are likely to have very different requirements in terms of the nature of a sample (rocks versus dust/soil, for example) or the location from which it is obtained (geologically challenging versus human safety), for example. We urge that science play the central role in designing and implementing MSR.

**Exploration program**

Although there is sometimes a perceived antagonism between the robotic science program and the human exploration program, this was not in evidence at our meeting. The MEPAG was fully engaged by the totality of the President's vision. However, as scientists, we want to ensure that the fully developed exploration program involves an appropriate level of science. It is imperative that NASA HQ work diligently to ensure that the Mars program remains a broad program that pays due attention to the science goals of the program, and that the input of the science community be given due consideration in programmatic decisions. Human exploration without science is correctly derided as "tourism" or as only "flags and footprints". The Apollo Program demonstrated the great benefits that accrue to both exploration and science when the program is run cooperatively.

**Lessons learned from MER**

A major topic of discussion involved trying to capture the lessons learned from the programmatics, operations, and science of the MER missions. While not science *per se*, these issues have a tremendous impact on our ability to do science, and we wanted to capture these issues now so that they could affect planning for future Mars surface missions in particular. Some of the most significant issues that were raised were:

- The MER mission demonstrated unequivocally the importance and value of mobility in carrying out science operations on the martian surface. Without rover mobility, for example, the Opportunity spacecraft would have sat tantalizingly close to "Opportunity Ledge", unable to investigate it close up and in detail and thereby make the discoveries that it has. In the words of one key Mars scientist and member of the MER team, trying to carry out this type of science mission without mobility "is just plain stupid". [Other types of missions require different types of mobility. For example, the Phoenix mission obtains vertical mobility via digging in order to access subsurface ice.]

- The ability to relay data back to earth through a communications relay via an orbiter, rather than relying solely on direct-to-earth communications, was fundamental to the success of the MER mission. The vast majority of the MER data was relayed back to Earth either through MGS or Odyssey, and, without such a relay, surface operations and scientific results likely would have been much more limited and operations planning would have been slower.

- There was tremendous scientific value in having two rovers instead of just one. With a goal of determining whether water had been present (and geologically significant) on the surface, and with two sites chosen for very different reasons and based on very different characteristics, it was not obvious that either would give definitive results. In fact, one did very readily, and the other is just now beginning to divulge its water-related secrets, and only grudgingly. Again in the words of a key Mars scientists, "Given the uncertainties of interpreting orbital data with limited ground truth, we should strive to always have more than one landed vehicle at each landing opportunity."

- MER has demonstrated in a compelling way the ability of a robotic spacecraft to carry out quantitative field geological investigations, a conclusion that was widely questioned prior to the mission.

- There is tremendous science value in selecting participating scientists (PSs) for a mission early enough that they can become fully integrated into the science team. Ideally, selection should be as much as a year prior to arrival or landing, so that the PSs can participate in the training for the mission, in the development of data reduction and analysis algorithms, and in the planning for the mission. Such was the case for MER, and it contributed substantially to the success of the mission. Other missions have had (or are planning) PSs added at orbit insertion or landing, and this severely impacts their ability to participate fully in the mission.

- Funding and planning for mission operations should reflect the likelihood of a longer-than-nominal mission duration. Experience shows that once a spacecraft gets past its initial EDL and check-out period, a long mission is very likely, and planning should allow for this. We recognize the inherent problem with a long planned lifetime increasing the estimated total mission runout costs, but these costs will be there whether we plan for them or not. In the case of MER, we also note that there appears to be broad consensus that money used for an extended mission is being incredibly well spent.

- A significant factor in the success of the MER missions was the effective way in which the science and engineering teams were melded into a single flight team, in contrast to the alternative in which distrust of each group by the other negatively impacts their ability to work together. MER demonstrated the high value of having the science and engineering teams working together rather than being antagonistic.

There were other lessons learned involving, for example, autonomy for target approach and instrument placement, the important role that students and post-docs played in mission operations and data analysis, the importance of adequate training prior to landing, landing precision, the importance of obtaining definitive non-Fe mineralogy, and vertical mobility (on MER, via trenching and ratting). We would be pleased to elaborate on these issues at an appropriate time.

**Update of the MEPAG Goals and Objectives Document**

Another major topic of the meeting was to discuss recent scientific discoveries and results, primarily from the Mars Exploration Rover and the European Space Agency Mars Express missions, and whether we need to update the MEPAG-sponsored Mars Science Goals and Objectives (G & O) document in light of them. As you know, the original 2001 G & O document has played a significant role in helping to determine the scientific directions of the Mars program, both at the mission level and at the future pathway level. MEPAG recently completed a year-long process of revising that document in order to bring it up to date and to improve the degree of scientific balance from the original 2001 version. The issue on the table at this meeting was whether we needed to make major changes in the 2004 document in the light of the new discoveries, or make only minor changes or perhaps no changes at all. Minor changes could be accommodated with a small amount of editing, while major changes would require further involvement of the community in order to maintain the "consensus" nature of the document.

In order to address this issue, we heard detailed science presentations from the MER and MEX science teams, and opened up the discussion to allow attendees to raise scientific results and issues that were not necessarily connected to these missions. The Goals and Objectives standing MEPAG committee (led at this meeting by Glenn MacPherson in the place of committee chair Jeff Taylor, who had a schedule conflict) met in the evening to discuss the results and to consider changes. They reported back to the MEPAG as a whole, and the attendees engaged in a spirited discussion of the significance of the results for the Goals and Objectives. The G & O committee recommended a small number of minor modifications to the report, and these were discussed and vetted by the attendees. Final changes will be transmitted to Glenn and to Jeff, and through them to the MEPAG Executive Committee. We anticipate that the Executive Committee will make any necessary final modifications prior to accepting the report, and that it will then be ready for formal publication in print. In light of the imminent deadline for proposal submissions for the Mars Science Laboratory and the important role played in proposal evaluation by the G & O document, we will not approve or publish any changes until after the proposal deadline. Further revisions will be considered following future major discoveries and/or new results.

**Pathways and program flexibility**

The scientists who attended the MEPAG meeting were very pleased with the opportunity to discuss the recent science results from MER, MEX, and elsewhere, and to consider their ramifications for planning the future of the Mars program. The flexibility that was intended to be built into the program, to allow the program to be responsive to discoveries, is both present and highly valued.

Part of this flexibility requires that we not "stovepipe" the program so that all future missions will automatically visit the very interesting region in which Opportunity landed. We will obtain fundamentally new types of data from the Mars Reconnaissance Orbiter and when the MEX data are fully integrated and synthesized, and we anticipate that these data will allow us to compare the Opportunity site with other locations and to determine whether possibly more interesting or exciting sites exist. In addition, scientific questions were raised about whether the geology and geochemistry at the Meridiani landing site would be conducive to the long-term preservation of the organic molecules that will be the major emphasis of the MSL mission and beyond. It is imperative that the landing sites for the future missions be kept open today, and that a well-defined and structured process be implemented in order to allow open debate and discussion of the scientific value of possible landing sites, in order to take advantage of the new data and to maintain the program flexibility to respond to ongoing discoveries.

**Science Steering Group reports**

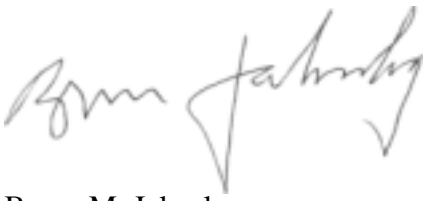
MEPAG heard reports on three SSGs, two of which have completed and submitted their reports and one of which is in process. The two completed reports addressed issues of organic contamination of samples delivered to instruments for the MSL mission (and, by analogy, other future missions) and the scientific direction of the Astrobiology Field Laboratory. The reports from these groups have been provided to the appropriate project offices at JPL, where they are being integrated into mission planning. The ongoing SSG addresses scientific linkages between the Moon and Mars, and is specifically in response to the announcement of the vision for NASA by the President; this SSG presented its preliminary report, and anticipates completing the report in the near future. MEPAG was singularly impressed with the quality and depth of the analysis carried out by each of the SSGs, the more so in that many of the questions addressed by them were originally ill-posed or ill-defined. I would be pleased to discuss the specific recommendations of the SSGs with you. One important conclusion that we would like to highlight is that these SSGs are an outstanding way to involve the science community in providing scientific input that feeds into the programmatic decisions that are to be made; there is no effective substitute or alternative.

**Summary observations**

Finally, let me comment on the overall perspective by MEPAG of the Mars program. The community consensus is that we are in a tremendously exciting time in exploring Mars. The MER mission has achieved some spectacular results. The remote sensing by the MEX, MGS, and Odyssey spacecraft is continuing to shed new light on science questions and to raise new questions. The upcoming slate of missions that are in advanced states of planning and implementation--MRO, Phoenix, and MSL--and the missions to follow that are in earlier planning are exciting science missions that address significant questions. And the renewed emphasis on the combination of exploration and science, and of human and robotic missions, is creating new opportunities and a sense of real advance. NASA is making great leaps forward, and we all are anticipating exciting and fundamental science to come from this program.

Please do not hesitate to contact me or any of the members of the MEPAG Executive Committee if we can provide additional details or elaborate on any of the issues discussed here.

Sincerely,



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