From: Raymond Walker [rwalker@igpp.ucla.edu]
Sent: Thursday, July 05, 2012 9:20 PM
To: Green, James (HQ-DG000)
Cc: Knopf, William (HQ-DG000); Grayzeck, Edwin J. (GSFC-6901)
Attachments: Senior Review-2.docx

Dear Jim,
Attached please find the report of the Planetary Senior Review panel.
Regards,
Ray

The NASA Planetary Senior Review panel met at the Columbia Maryland Double Tree Hotel on June 26 -29, 2012. The panel evaluated proposals and oral presentations from eight currently flying planetary missions five from the Mars Program (Mars Exploration Rover (MER), Mars Odyssey, Mars Express (MEX), ASPERA and Mars Reconnaissance Orbiter (MRO)), Lunar Reconnaissance Orbiter (LRO), Cassini and Deep Impact (DI-3). We rated each mission on its science merit and technical merit and then took a weighted average (60% for science merit and 40% for technical merit). The numerical ratings for each mission are given in Table 1.

Mission	Science (Raw Score)	Technical (Raw Score)	Science Weighted	Technical Weighted	Overall Weighted
Cassini	4.86	4.18	2.92	1.67	4.59
LRO	4.14	4.23	2.48	1.69	4.17
MEX	4.13	4.00	2.48	1.60	4.08
MRO	3.95	3.68	2.37	1.47	3.85
MER	3.75	3.17	2.25	1.27	3.52
ASPERA	3.00	3.33	1.80	1.33	3.13
Odyssey	3.00	3.17	1.80	1.27	3.07
DI 3	2.46	3.04	1.48	1.22	2.69

Table 1 The ratings of the proposals

In Table 1 the ratings are based on a five point scale. An excellent proposal was rated 5 and a poor proposal 1. Please see the attached spreadsheet for different displays of the ratings. Several of the Mars missions provide services to the overall Mars program e.g. by providing communication services for experiments on the surface of Mars or helping to characterize landing sites and atmospheric conditions on landing. We did not consider these services in our ratings but concentrated on the science and the technical aspects of the science proposals. The overall weighted score was obtained by adding the science weighted score to the technical weighted score. The Cassini mission received the highest overall rating of 4.59 or E/VG. LRO (4.17) and MEX (4.08) both had overall scores above VG while MRO was just below (3.85). The other four missions MER (3.52 or VG/G), ASPERA (3.13 or G), Odyssey (3.07 or G) and DI 3 (2.69 or G/F) were significantly lower.

Some of the missions proposed to address the potential 85% budget by taking most of the reductions in the science part of the mission. The panel felt that this was short sighted. It does little good to collect the data if the science community is unable to validate and analyze them. The panel felt that more balanced reductions involving both science and operations could and should be applied in cases where the full funding is not available.

Below we briefly summarize the panel findings for each mission. They are listed in the order of their overall score.

Cassini

The Cassini mission received our highest rating. It was the only mission to achieve a consensus rating of excellent for science merit. The Cassini mission has contributed ground breaking science in the past and has the potential for ground-breaking science in the future. The CSM-2 plan is focused on extending the temporal baseline of observations into northern summer, thus revealing temporal variations as well as observing the northern hemispheres of the planet and the satellites which were not illuminated at the start of the mission. CSM-2 will search for evaporation of Titan's northern lakes and wave action on them, investigate formation of atmospheric storms at Saturn and Titan, study time variability of the plume jets on Enceladus, conduct new detailed investigations related to the tenuous atmospheres and possible activity of Dione and Rhea, expand investigations into ring structure and dynamics, and investigate the effects of solar maximum on Saturn's magnetospheric interactions with the moons. The continued investigation of the multiple, changing periods of the auroral radio emissions and the particle and fields parameters are potentially ground breaking. The CSM-2 science investigations follow up on prior investigations and discoveries and take advantage of the changing seasonal and solar activity conditions. They have excellent potential for new scientific discoveries.

We found that the Cassini 100% budget is highly cost effective for supporting science. The mission streamlined its operations for CSM-1 in 2010 although it still remains the most expensive mission. There has been some loss of capability in the instruments. For instance most recently the Cassini Plasma Spectrometer was turned off and has likely failed with an apparent electrical short. The overall rating for technical merit is very good.

Lunar Reconnaissance Orbiter

The proposed extended mission for LRO builds upon the previous discoveries of LRO with specific emphasis on polar volatiles, early history of the Moon, impact history and processes, and interaction of the Moon with its external environment. It received our second highest rating for science (very good). The proposed orbit with a lower perilune (30 km) near the south pole will augment previous ground-breaking discoveries with the likelihood of additional major scientific discoveries such as improved constraints on heat flow values based on the cold temperatures of the crater floors near the poles. The distribution of volatiles and their relationship to the surface temperature will be refined in the extended mission.

The proposed bistatic radar operation investigating polar volatiles will be an order of magnitude more sensitive than the original monostatic observations investigating polar volatiles. For target areas with significant near-surface deposits of almost pure water ice, the Mini-RF bistatic radar operation could provide additional evidence for the presence of such ice.

Spacecraft and instruments are in very good to excellent health and should enable completion of extended mission objectives. Costs are effective in supporting science and infrastructure

with the guideline (100%) budget. The 85% budget cut the bistatic radar operation. The discussion related to orbit changes and instrument utilization (e.g. bi-static radar) is detailed and logical.We rated the technical merit of LRO as very good.

Mars Express

NASA provides support for US investigators on the European Space Agency's Mar Express Mission. The proposal evaluated for the Mars Express mission did not include the APSERA instrument, which was considered separately (see below). Proposed atmosphere/ionosphere investigations have the potential to produce ground-breaking results during the 2013 solar maximum. They will provide insight on escape of atmospheric components, context for the upcoming MAVEN mission, improved estimates of water sequestered in surficial and subsurface deposits, images of the farside of Phobos which has not been observed by other orbiters, and continuation of a number of collaborations with instruments on US missions. Some of these investigations have the potential for ground-breaking scientific discoveries. In particular, operation of the atmosphere/ionosphere experiments (ASPERA, MaRS, MARSIS, PFS, SPICAM) during the expected 2013 solar maximum may provide ground-breaking results about how the Martian atmosphere responds during periods of high solar activity. We rated the science from MEX as very good.

The guideline budget is reasonable for the level of science and infrastructure support proposed. Under the 85% budget option, US participation in the MEX mission will be severely reduced. Spacecraft health is good with only a few possible mission-threatening issues. Instrument health is good to excellent and it will support the measurements required to carry out the proposed investigations during the extended mission. We rated the technical merit of MEX as very good.

Mars Reconnaissance Orbiter

The MRO extended mission proposal builds on the scientific goals of the prime mission. It has been very productive scientifically and we find that the proposed investigations will keep it productive. We rated MRO science as very good. Some of the investigations include: Investigate the diversity of aqueous environments spatially and with time, as indicated by mineralogy and morphology; measure the extent of groundwater discharge with elevated temperature and favorable pH that might have persisted into Hesperian time; quantify how large the interannual variability of non-uniform distributions of dust with altitude which is critical to understanding radiative forcing of atmospheric circulation and model simulation of Mars atmosphere; determine the locations and probable cause of Recurring Slope Lineae (briny flows?) imaged currently on the warmest slopes; i.e., in the southern mid-latitudes near perihelion and on equator-facing slopes. Define the 3D extent of internal layering and erosional unconformities in north polar layered deposits, for comparison with predicted ice retreat episodes in climate models. Finally, continue and extend the ongoing high-resolution gravity studies, for which the MRO orbit is the best of any active Mars mission.

Spacecraft and instruments are generally in very good to excellent health with only a few issues. The 100% guideline budget is sufficient to accomplish all proposed science and programmatic goals, but both will be reduced under the 85% budget scenario. Mission operations will continue as during the first extended mission, will remain flexible, and can accommodate follow-up observations for any unexpected discoveries. However, in retaining the full operations staff, there does not appear to be significant effort being applied to move to more efficient operations. We gave the technical merit a rating of good to very good.

Mars Exploration Rover (MER)

The emphasis of the proposed extended mission is to investigate the geologic context of exposures of ancient and aqueously altered materials at Endeavour Crater and extend the timeline of atmospheric observations from the Martian surface. The proposed investigations have the potential to provide new ground-breaking scientific results, because such ancient materials have not been previously characterized by in-situ investigations. However, the demise of Mini-TES and the Mossbauer Spectrometer will hamper mineral diagnostics and thus the interpretation of the processes which have operated in this area. The remaining instruments are capable of conducting the proposed investigations if the rover is able to reach the crater rim outcrops. The value of the science is high so long as the rover can reach the outcrops containing phyllosilicates. MER was rated very good for science merit.

The MER mission has an outstanding record of involving students. This proposal has a clear plan to bring young collaborators (graduate and undergraduate) into the mission.

The main concern is the proposed staffing of 43 total FTE with 18 individuals actually full time. The project's discussion of the command cycle iteration of downlink, data evaluation, planning, sequencing, checking, and uplink on Earth-Mars time phase did not seem to fully justify the level of staffing. They did not provide an assessment of what staff reductions could be made without increasing risk. The project did state that at 85% funding there would be 25% fewer operation cycles due to the fact that they could not plan rover operations 2 days in a row in addition to losing days due to Earth and Mars length-of-day differences.

In terms of risk management, the rover is treated as a consumable system. System health is continuously monitored, the battery is re-conditioned regularly and driving is done both forward and in reverse to even wear on gears. Now it is done mostly in reverse at present. It is noted that the avionics is a single string system where a failure in a critical component would mean end of mission. The technical merit rating was good.

ASPERA

The ASPERA experiment suite is a US contribution to the ESA Mars Express mission but was reviewed separately. The ASPERA experiment consists of four instruments – the Electron Spectrometer (ELS), the Ion Mass Analyzer (IMA), the Neutral Particle Imager (NPI) and Neutral Particle Detector (NPD). ASPERA studies the interaction of the Martian

atmosphere with the solar wind as well as monitoring the plasma environment in Mars orbit. Results from previous years have provided important new insights into the plasma environment at Mars as well as how the solar wind interacts with the Martian atmosphere. The investigations proposed here extend the study of the Martian atmosphere response to solar wind to a time of maximum solar activity and thus have the potential for ground-breaking scientific discoveries regarding the identification of solar drivers of atmospheric escape during this period of increasing solar activity. There also are excellent prospects for synergy with the MAVEN mission, which may result in ground-breaking science. Data from the ELS and NPI instruments are delivered to the PDS every 6 months, but data delivery from the IMA is severely behind schedule. Publications by non-mission team members indicate that the ASPERA data are being utilized by the general scientific community to conduct new research but the publication record of the US ASPERA team is limited. ASPERA was rated as good in science merit.

Spacecraft and instruments are generally in good health and expected to provide the proposed data during the extended mission. The 100% baseline budget effectively supports both science and infrastructure, but the 85% budget will reduce efforts in both areas and will impact data deliveries to the PDS. The cost effectiveness is limited by the low science publication rate. ASPERA was rated good on technical merit.

Mars Odyssey

This extended mission will continue investigations by the THEMIS, NS, and HEND instruments of the surface, atmosphere, and radiation environment at Mars. THEMIS and NS investigations primarily extend the timeline over which surface and atmospheric observations have been made by these instruments, providing additional insights into temporal variations. THEMIS spectral data are complementary to the spectral ranges of CRISM and OMEGA, thus enabling better distinction of surface mineralogies. HEND will continue investigations of the radiation environment above the Martian atmosphere during the 2013 solar maximum to provide information complementary to data obtained at the Earth-Moon system and Mercury about galactic cosmic ray penetration in the solar system. HEND data also will be compared with radiation analysis by the MSL on the surface, providing simultaneous measurements for the first time of radiation above and below the Martian atmosphere.

Most of the proposed science from Odyssey was considered to be incremental and to have little chance for ground breaking science. There are two new science objectives for the fifth extended mission: measure cosmic background radiation from orbit to coordinate with MSL observations on the surface and identify chloride salts exposed in surface outcrops. HEND will do follow up work that was started by MARIE (which has since failed), using a cross calibration of HEND and MARIE data sets when both instruments were taking data. The HEND data will fill in the gap until MAVEN goes into orbit, and will deliver important (possibly breakthrough) data on the radiation environment at Mars and its seasonal cycle.

Odyssey was rated as good for science merit.

Odyssey has been in orbit for 11 years so even though risk mitigation procedures are described there is a chance that a mission-ending event could occur such as through the loss of the single spacecraft battery. Instruments to be used in the extended mission are rated in excellent health, so the option in the 85% budget of turning off NS and HEND seems extreme, especially considering the potential science benefit of the HEND radiation measurements during solar maximum and in comparison to the surface radiation environment to be measured by MSL. Odyssey was rated as good in technical merit.

Deep Impact 3

The DI Team proposes to use the Deep Impact Flyby Spacecraft as a planetary observatory to investigate volatiles of three comets, atmospheric methane on Mars, aurorae on Jupiter, microlensing events by exoplanets, and to identify near-Earth objects (NEO). Compared with ground-based or Earth-orbiting observatories, DI-3 importantly offers very long dwell time (days, or even weeks) on a chosen target, and thus it excels at studies that require long observational sequences in time. The comet observations will uniquely measure three key volatiles (H_2O, CO_2, and CO) and also provide unique coverage of temporal variability at both optical and infrared wavelengths. The observations will include examination of an evolved comet (Encke). Deep Impact also will search for either permanent or transient methane on Mars and will monitor the Jovian aurora (H_3^+) in support of Juno. Finally, the team proposes to characterize exoplanets by observing microlensing events that are discovered and observed from Earth. All these observations are confined to windows when the solar elongation is appropriate. In the time between windows, a search for NEOs will be conducted, a task for which the spacecraft is in an ideal location during the near-perihelion portions of its orbit. These activities will keep the spacecraft and its team available with full functionality to uniquely support both Rosetta and Juno in the following 2-year cycle. The proposal did not demonstrate that the Mars methane objective could be achieved. The microlensing investigation was not sufficiently developed. While Deep Impact is the only spacecraft currently able to measure CO_2 easily (a measurement critical for investigating comets), it was not demonstrated what ground-breaking science would result from DI-3. DI-3 was rated fair on science merit. The DI-3 mission does involve international cooperation with Europe.

DI-3 proposes an economical budget for the next two years for an extended mission that includes new science observations. The spacecraft and instruments are in good health, although there are a number of issues that are cause for concern. The spacecraft is operating with RIU A after the failure of RIU B in 2011. Problems in 2008 caused a decision to switch from operating on TWTA-A to TWTA-B. The spacecraft has been operating on TWTA-A since a safe mode event triggered an autonomous switch back to TWTA-A in April 2012. DI-3 was rated good for technical merit.

NASA Planetary Senior Review panel – Operations

The panel had the task of reviewing 8 missions in three and a half days. An extra half day would have been useful. The panel held two teleconferences prior to the review. The first was organizational. Between the two teleconferences each member of the panel read at least one of the proposals. At the second teleconference the panel formulated both general and detailed questions about the proposals that were communicated to each of the proposing teams. At the face to face review the presentationsconcentrated on answering these questions. This approach turned out to be very useful. The support for the meeting was excellent. The NRESS staff did an excellent job of supporting the meeting.

End of Report