

REPORT
of the
Planetary Science Subcommittee
of the NASA Advisory Council Science Committee

Orlando, Florida
7 October 2007

Introduction

The Planetary Science Subcommittee (PSS) of the NASA Advisory Council (NAC) Science Committee met for the sixth time on 7 October 2007 at the Rosen Centre Hotel in Orlando, Florida. Eleven of the 17 subcommittee members attended the meeting, and one member participated by teleconference.

The agenda (attached) included a number of presentations and discussion topics. James Green, Director of the Planetary Science Division (PSD) of NASA's Science Mission Directorate (SMD), briefed the subcommittee on Division activities, including those in the Mars Exploration Program (MEP), as well as responses to PSS and NAC recommendations from earlier meetings. Following an extended discussion among subcommittee members of topics from that briefing, the subcommittee heard presentations by chairs or representatives of the analysis groups — including the Venus Exploration Analysis Group (VEXAG), Lunar Exploration Analysis Group (LEAG), Mars Exploration Program Analysis Group (MEPAG), Outer Planets Assessment Group (OPAG), and Curation and Analysis Planning Team for Extraterrestrial Materials (CAPTEM). The attendance during the afternoon of SMD Associate Administrator (AA) Alan Stern permitted a question and answer session with the AA. The one-day meeting ended with the presentation of a proposal to add a new assessment group for asteroids, comets, and other small bodies; a review of subcommittee findings and recommendations stemming from the day's discussion; and the scheduling of the next subcommittee meeting.

In general, the PSS applauds the efforts by both Jim Green and Alan Stern to seek to maximize the scientific return from all PSD programs. Creative budgetary moves, aggressive containment of mission cost growth, timely decisions on new missions, and thoughtful attention to the division's research and analysis programs constitute a refreshing approach to programmatic management at both the divisional and directorate levels.

Flagship Missions

The recent studies of candidate flagship missions to the outer solar system — targeting Europa, Titan, Enceladus, and the Jovian system (Ganymede) — have been submitted, and site visits to the study teams are scheduled to be completed by November. The PSS looks forward to a report on the down-selection of outer planet flagship missions at our next meeting.

The PSS was informed that PSD has initiated two concept studies for missions to cost no more than 1 billion dollars, a Comet Surface Sample Return mission and a Venus In Situ Explorer (VISE). The former study is being led by the Johns Hopkins University Applied Physics Laboratory, and the latter by the Jet Propulsion Laboratory.

PSD plans that its flagship missions will alternate between the outer and inner solar system. The currently operating flagship is Cassini, and the next flagship mission to be launched is the Mars Science Laboratory (MSL). By this alternating destination rule, the next flagship mission

thereafter will be one of the outer solar system missions now under study, and a Venus flagship mission might be a candidate to be next in the queue. The PSS is supportive of efforts to maintain a broad perspective on flagship mission targets, but it is not immediately clear how a Comet Nucleus Cryogenic Sample Return mission or a Mars Sample Return (MSR) mission fits within such an alternating destination algorithm. Nor is it clear how potential international partnerships might affect the sequencing of flagship mission candidates. The subcommittee suggests that solar system location be one of several criteria for flagship mission selection, and that such criteria also include scientific primacy and technical readiness.

The PSS devoted considerable attention to the recent “replanning” of MSL. Jim Green described the history of mission development and cost, set in the context of constraints imposed by other missions supported by the Mars Exploration Program (e.g., increases to the development and operations costs of Phoenix and approval of Mars Exploration Rover extensions through GFY 2008 and, if the rovers are still operational, GFY 2009). MSL was confirmed in August 2006 at a cost of \$972M. The MEP added \$32M to the mission reserves at that time to bring the reserve fraction to 35%. Early in 2007, approximately \$20M in descope options were exercised; most of those descopes dealt with the mission payload; e.g., the tunable laser spectrometer (TLS) on the Sample Analysis at Mars (SAM) instrument suite, the sample crusher, and the Chemistry and Mineralogy (CheMin) dual X-ray source. In June sample caching was added to MSL, but the cost for this addition came from SMD rather than the Mars Program. Also in June, however, the MSL project estimated that it would need an additional ~\$75M to complete the mission as then currently planned. A variety of sources of cost growth could be identified, including payload instruments, the mechanical design of the rover body, the corer/drill, sample acquisition and handling hardware, thermal protection system testing, parts procurement, and fabrication services and labor.

Because \$75M in funds could not have come from elsewhere in the Mars Exploration Program without shutting down operating spacecraft and cutting research and analysis programs, a multi-pronged mitigation strategy was adopted. An independent science team defined a science floor of instruments, the MSL project and Mars Program recommended a menu of descope options, and the Mars Program allocated new funds from program reserves. The descope options were presented in three groups: a recommended group, a second group of potential descopes “with programmatic implications,” and a third group not recommended because high scientific or technical risk would be introduced. A number of descope options were exercised, including nearly all of the options in group 1 plus one of the options from group 2, resulting in a savings of \$26M. Together with the \$36M in new funds from Mars Program reserves, \$62M in added mission capacity was provided, and the payload remained well above the science floor as defined by the independent science team.

The MSL descope that most concerns PSS was the decision not to provide further NASA funds for the Chemistry Camera (ChemCam) instrument. This descope was the only one exercised from the second group of options presented by the MSL project and Mars Program. The ChemCam, which uses laser-induced breakdown spectroscopy for chemical analysis and micro-imaging, is the only MSL instrument that can provide remote elemental chemical information on both dust-free and weathered materials, including the light elements H, Li, Be, B, C, N, and O that are central to issues of past habitability. Instrument development, now within \$2M of completion, has been a partnership between the Los Alamos National Laboratory and the French space agency (CNES), with the French having contributed \$23M toward development and having agreed to a 50-50 split of instrument operations costs. During discussion, Jim Green emphasized that he hopes that a solution will be found to include ChemCam in the MSL payload, and he added that the MSL budget retains the full cost of integrating ChemCam into the spacecraft as well as the Phase E support for the instrument. Because of both the instrument’s scientific promise and the potential impact of its removal on future international collaboration, as well as the instrument’s importance for maximizing the effectiveness of sample caching in

preparation for MSR, **the PSS urges that NASA and the developers of ChemCam make every effort to ensure that this important instrument fly on the MSL mission.**

New Frontiers Missions

Regarding the New Frontiers mission line, the PSS was pleased by the discoveries made by the New Horizons spacecraft as it flew by the Jupiter system in February, and the subcommittee understands that the Juno mission to Jupiter is on track for a launch in August 2011. The PSS awaits the findings of the National Research Council study on New Opportunities in Solar System Exploration (NOSSE): An Evaluation of the New Frontiers Announcement of Opportunity, expected early next calendar year. The subcommittee understands that the NOSSE study group was asked to consider the wisdom of including Mars among the potential targets for the next New Frontiers opportunity.

Discovery Missions

The PSS was pleased to hear of the successful launch, only 10 days prior to our meeting, of the Dawn mission to rendezvous with main belt asteroids Vesta (2011 arrival) and Ceres (2015 arrival). The only other Discovery mission still in its nominal operational phase is MESSENGER, whose Mercury flyby in January will be the first encounter of that planet by a spacecraft in nearly 33 years.

The PSS understands that the evaluation of the three Discovery mission candidates currently under consideration for selection — the lunar Gravity Recovery And Interior Laboratory (GRAIL) mission; the Origins Spectral Interpretation, Resource Identification, and Security (OSIRIS) mission to return a sample from a near-Earth asteroid; and the Vesper orbiter to study atmospheric chemistry and dynamics at Venus — has been completed. A down-selection announcement is expected by December.

The PSD is to be congratulated for expanding the range of potential Discovery (and Scout) missions by calling for concept proposals for missions that can take advantage of a Stirling radioisotope power system (RPS). The RPS, which would provide up to 280 W of mission power, would be government-furnished equipment not counted against the mission cost cap. The PSS looks forward to hearing how the community responds to this call.

A discussion of cost containment in the context of the Discovery Program raised the question of whether the next Announcement of Opportunity (AO) should explicitly solicit mission proposals that cost substantially less than the program cost cap. The consensus of the PSS was that such a solicitation was a good idea as long as there was suitable language in the AO describing how lower cost mission concepts and more ambitious mission concepts would be considered in mission selection.

Scout Missions

The PSS was pleased to see the successful launch of Phoenix on 4 August and awaits eagerly its arrival at Mars next May. The subcommittee also understands that a final down-selection from the two proposals for the 2011 Scout opportunity that were awarded Phase A funds — Mars Atmosphere and Volatile Evolution, or MAVEN, and The Great Escape (TGE) — will be announced in January.

Missions of Opportunity

The PSS was pleased to hear that PSD will issue a call for missions of opportunity (MOOs) in 2008 and that the division plans to make similar calls on an annual basis as the budget permits. Separating the MOO selections from those for the Discovery and Scout Programs should enable a greater responsiveness to opportunities as they arise, particularly on non-NASA spacecraft.

The subcommittee was also pleased that three MOO investigations from the last Discovery announcement of opportunity were selected (EPOXI, combining the Deep Impact extended Investigation of Comets — or DIXI — and the Extrasolar Planet Observations and

Characterization — or EPOCh, both utilizing the Deep Impact spacecraft; and Stardust NExT, to reuse the Stardust spacecraft to visit Tempel 1, the Deep Impact target comet) and that two missions of opportunity from the last Scout competition (Mars Organic and Oxidant Detector and Mars Organic Molecule Analyzer) have been given Phase A funds for possible flight on the European Space Agency (ESA) ExoMars mission.

Research & Analysis Programs

The PSS applauds the increases that PSD has made to the Research & Analysis (R&A) programs in NASA's GFY 2008 budget. Although this budget has not yet been passed by Congress and signed by the President, it calls for an increase to R&A in PSD by 20.4%, including a 29% increase in the budget for R&A programs in astrobiology. These increases constitute a substantial restoration of the damaging cuts made to R&A across the division, and particularly in astrobiology, in GFY 2006 and 2007. The PSS is particularly pleased by the pervasive SMD policy, instituted by Alan Stern, that R&A is "off the table" when cost overruns in flight programs raise the question of where additional resources might be found.

Other positive changes to the R&A programs were described or would be announced at the American Astronomical Society Division for Planetary Sciences meeting that was to follow the PSS meeting. These changes included opening the Discovery Data Analysis Program to the analysis of past data from any planetary mission, as well as to the restoration of past data to the point that they can be archived with the Planetary Data System. Opportunities for grants lasting as many as 4 or 5 years will be introduced in several R&A programs at the next proposal call, and the options for such longer grants will be extended to other programs in later years.

Lunar Program in SMD

Jim Green reported that the PSD is looking to expand the range of lunar programs that it will be supporting. A budget "wedge" amounting to \$22M in GFY 2008 will be devoted to lunar activities. The Lunar Advanced Science and Exploration Research (LASER) Program, jointly supported by SMD and the Exploration Systems Mission Directorate (ESMD), received 170 proposals in response to the most recent solicitation, one third addressing basic research objectives, one third addressing applied research objectives, and one third addressing a mix of both. By agreement, SMD will support the first and third types of investigation, and ESMD will support the second type. The Lunar Reconnaissance Orbiter (LRO) will be an important component of SMD-sponsored exploration of the Moon; although LRO is an ESMD mission and will be operated by ESMD for the first year in orbit, operations will transfer to SMD thereafter.

Following a report from LEAG on their annual meeting, held the week before the PSS meeting, several issues related to NASA's lunar architecture and planning efforts were discussed. LEAG expressed the concern that the original Vision for Space Exploration may have become blurred during the lunar exploration architecture planning process. This impression was conveyed in several ways at the LEAG meeting. In presentations on the latest report of the Lunar Architecture Team (LAT), it was unclear how the lunar outpost would become sustainable to allow for extended stays on the lunar surface (instead it appeared as though everything for life support would have to be taken from Earth for every trip to the Moon). The lunar lander was described as having a much reduced cargo capacity (700 kg to the lunar surface was the worst-case scenario) compared with earlier descriptions. The role of international participation was unclear (this perception was voiced by international representatives on the first morning of the meeting; there is a desire to collaborate but NASA has been sending mixed signals as to when agreements might be discussed). There seemed to be no "feed forward" to Mars in the latest LAT report (LAT-2), a situation highlighted by the fact that LAT-2 does not include in situ resource utilization (ISRU) in the critical path, despite the fact that a consensus at the LEAG meeting was that ISRU is essential for outpost sustainability and for feeding forward to Mars. **Therefore, the PSS recommends that the NAC take steps to ensure that in planning for the return to the Moon NASA keep its highest-priority goals in sharp focus.** These top-priority goals should include science, notwithstanding the fact that science was deemed not relevant to

lunar exploration goals by some representatives of the LAT at the LEAG meeting. The PSS was heartened to hear from Alan Stern that science will be an important component of human surface activities associated with the lunar outpost. Not all potential outpost sites will yield a comparable variety of compelling science, however, as documented in the LAT and National Research Council reports on lunar exploration. Because science is expected to be the dominant activity of outpost astronauts, according to LAT estimates, **the PSS recommends that science should be considered a high priority in the site selection decision for a lunar outpost.** Periodic briefings to the PSS are requested on progress made toward meeting this recommendation. On the basis of community input at the LEAG annual meeting, **the PSS recommends that NASA review the Lunar Precursor Robotic Program after LRO with the aim of devising innovative routes (e.g., international or commercial participation, individual state involvement) to undertake robotic exploration missions needed to initiate the next era of lunar and solar system exploration, including ISRU demonstrations.**

At the request of the NAC, CAPTEM completed an analysis of sample mass that must be accommodated within the Constellation Architecture to fulfill lunar science as documented in the LAT-1 and National Research Council reports on lunar exploration. CAPTEM concluded, and the PSS endorsed their finding, that the Constellation Architecture should accommodate between 250 and 300 kg of samples from the lunar surface. The PSS should be briefed periodically on progress made toward meeting this recommendation.

At the encouragement of Jim Green, **the PSS asked LEAG to prepare a “Lunar Goals Roadmap” for communication to NAC and to NASA.** That document will include not only science goals for lunar exploration but will also highlight needed technology developments, “on-ramps” for commercial and international participation, and a “feed forward” focus on the exploration of Mars as beyond.

Launch Vehicles

At its last meeting in June, the PSS expressed concern over the imminent loss of Boeing’s Delta II expendable launch vehicle, which has served as the workhorse launch vehicle for PSD missions. The subcommittee recommended “that NASA decide expeditiously on a future approach to acquiring appropriately sized launch vehicles and make that decision and the supporting documentation public.” No major news on this topic was presented at this PSS meeting, so the subcommittee looks forward to a progress report on options for the procurement of Delta-II-sized launch vehicles at one of its next meetings.

Containment of Mission Cost Growth

The PSS held a fruitful discussion with Alan Stern on the compelling rationale for containment of mission costs after selection. Although mission cost growth was one of several factors in the recent decision by SMD to require spaceflight mission or instrument leadership experience for individuals proposing to serve as mission Principal Investigators to the Discovery, Scout, and New Frontiers Programs, cost growth has been problematic for programmatic (i.e., strategic) missions as well as for PI-led missions. The PSS accepted Stern’s request for assistance in conveying to the planetary science community the importance of controlling mission cost growth and the consequences of failing to do so. In return, the PSS asked to be given information on the cost containment history of past missions as a tool to help raise community consciousness. Jim Green was asked by Stern to provide that information to the subcommittee.

In the context of experience required prior to proposing to lead a mission as Principal Investigator, the planetary science community has far fewer options for suborbital missions than do the astrophysics and heliophysics communities, although we understand that PSD will be working to expand such opportunities. More generally, a vigorous campaign to publicize potential “on-ramps” to the types of flight experiences that would qualify a planetary scientist for PI status would be broadly welcomed.

Proposal for a Small Bodies Assessment Group

There is a large community of solar system scientists who focus their research on the smaller bodies of the solar system, including asteroids, comets, meteorites and their parent bodies, dust particles, irregular satellites, Trojans, Centaurs, and Trans-Neptunian Objects (TNOs). The interests of this community have been represented to date by OPAG, but the interests of OPAG focus on the giant planets and their major satellites, and comparatively few representatives of the small bodies community have participated in OPAG deliberations.

Representing a self-organized steering committee, PSS member Hal Weaver presented a proposal for adding a Small Bodies Assessment Group (SBAG) to the mix of analysis and assessment groups providing input to PSS and, through PSS, to the NAC. The scope of SBAG would encompass all small bodies that orbit the Sun, as well as meteorites, dust, and the irregular satellites (including Phobos and Deimos). Following NAC and NASA approval of an SBAG, a Small Bodies Workshop will be planned to develop an organizational structure, to draft an outline for a white paper laying out a strategy for the exploration of small solar system bodies, and developing a community web site. The PSS regards the proposal for an SBAG as a compelling means to ensure the full participation in NASA planning of the solar system small bodies community. **The PSS recommends that NASA and NAC approve the formation of a Small Bodies Assessment Group before the end of this calendar year.**

Activities of Assessment and Analysis Groups

VEXAG co-chair Janet Luhmann summarized current VEXAG activities and the principal issues facing the Venus science community. VEXAG has completed a white paper outlining key science goals for Venus exploration and is promoting the development of technologies that will be needed to operate in the extreme environment of the Venus surface and lower atmosphere. The group provides a forum for the discussion of U.S. support for non-NASA missions to Venus, including ESA's Venus Express and planned European Venus Explorer (EVE) missions and the Venus Climate Orbiter approved by the Japan Aerospace Exploration Agency (JAXA). VEXAG considers that the Venus In Situ Explorer (VISE) mission remains a compelling candidate for a New Frontiers mission, and the group is organizing the kickoff of a Science and Technology Definition Team (STDT) for a Venus Flagship Architectures Mission study. The next VEXAG meeting will be 4-5 November in Greenbelt, Maryland. News on VEXAG activities is posted regularly on <http://www.lpi.usra.edu/vexag/>.

LEAG chair Clive Neal summarized recent LEAG activities, with an emphasis on outcomes from the LEAG Annual Meeting, held 1-5 October in Houston. The group expressed concern, echoed by PSS (see above), that the overarching goal of returning to the Moon — to learn how to live and work on another planetary body — was becoming blurred by the current planning process, e.g., the most recent Lunar Architecture Team (LAT-2) report. A second concern expressed is the lack of an aggressive robotic campaign in preparation for the renewed human expeditions to the lunar surface. Such a campaign could be enabled by leveraging with commercial sector participants interested in surface technology demonstrations leading to in situ resource utilization. The lunar surface exploration program would benefit from targeted technology development emphasizing simple concepts. LEAG has offered to produce a "Lunar Goals Roadmap" that will integrate science goals with other exploration goals, and the PSS has asked LEAG to proceed with the preparation of such a document (see above). News on LEAG activities is posted regularly on <http://www.lpi.usra.edu/leag/>.

Relevant to lunar surface exploration, Clive Neal also presented a summary, prepared by PSS member Arthur Snoke, of recent activities of the Field Exploration Advisory Team (FEAT). FEAT convened a session at the LEAG meeting held the previous week in Houston and will gather again during the annual meeting of the Geological Society of America in Denver later this month.

MEPAG was represented at the PSS meeting by member Vicky Hamilton, who presented a summary of MEPAG activities prepared by MEPAG Chair Jack Mustard. In response to a request from the National Research Council's NOSSE committee, MEPAG provided input on the possibility of expanding New Frontiers mission targets to include Mars. MEPAG views this option as one that could open opportunities to advance those Mars science goals not currently met in the MEP. A mission that has strong science backing and could fit within the New Frontiers cost cap, for instance, is a geophysical network. MEPAG cautions, however, that if the New Frontiers opportunity offsets the deletion of one or more strategic missions from the MEP, such a trade would result in a loss of capability in the Mars Program and would slow the pace of Mars exploration. Two Science Analysis Groups (SAGs) have been formed in response to NASA's recent commitment to Mars Sample Return by 2020. The MSL Cache SAG was formed in partnership with the NASA Astrobiology Institute to assess the capability of the MSL caching system to address science questions. The Next Decade MSR SAG was formed with two objectives: to analyze questions related to the kinds of samples needed to address Mars exploration goals, and to analyze the primary non-sample objectives that can be achieved by missions that lead to MSR. This second objective will include an emphasis on prioritizing MEP strategic missions for 2013 and 2016. The efforts of this SAG will be complementary to CAPTEM studies, and there is therefore overlap in membership of these groups. MEPAG is concerned about the science impacts of the descopes to the MSL payload, notably the diminished imaging capability and the loss of the only remote geochemical capability on MSL. The next MEPAG meeting will be 20-21 February near Pasadena, California. News on MEPAG activities is posted regularly on <http://www.mepag.jpl.nasa.gov/>.

By telephone, OPAG chair Fran Bagenal provided an update on OPAG activities. OPAG had not met between the time of the last PSS meeting in June and this meeting, so the report was comparatively brief. She gave a high-level review of the four outer planets flagship mission concepts, as well as the expected down-selection by NASA Headquarters in November. One concern expressed by OPAG is that progress in the development of enabling new technologies for outer planet missions (e.g., aerocapture flight qualification, balloon technology development, high-efficiency RPS development and qualification, and low-temperature materials and systems) is too low, and the group suggests that PSD review its current technology investments. Healthy instrument development programs and supporting laboratory studies are also key elements of a strong outer planet exploration effort. The next OPAG meeting is 8-9 November in Greenbelt, Maryland. News on OPAG activities is posted regularly on <http://www.lpi.usra.edu/opag/>.

CAPTEM chair Chip Shearer summarized recent CAPTEM activities. At the Tempe Workshop on Lunar Science, CAPTEM had been asked to analyze the sample return mass needed to accomplish the primary science objectives of lunar surface exploration. A final report on that analysis was completed and forwarded to the NAC. CAPTEM was also asked to review the capability for curation of future samples, and the group co-sponsored with LEAG and the Outpost Science and Exploration Working Group (OSEWG) a workshop on sample collection and return during lunar outpost activities. CAPTEM is continuing to plan for the preliminary examination of Stardust interstellar dust samples as well as the ongoing analysis of interplanetary dust particles (IDPs). CAPTEM members are working with MEPAG SAGs to provide input on sample documentation and preservation in the context of sample caching on MSL and an MSR mission. News on CAPTEM activities may be found at <http://www.lpi.usra.edu/captem/>.

As a final action, the PSS scheduled its next meeting for 3-4 March 2008 at the Carnegie Institution of Washington in Washington, D.C.

Planetary Science Subcommittee Meeting
7 October 2007
The Rosen Centre Hotel
9840 International Drive
Orlando, Florida 32819

7 October (8:30 AM – 5:00 PM)

8:30	Welcome & Administrative Matters	Sean Solomon, Michael New
8:45	Planetary Science Division Update	Jim Green
10:45	Break	
11:00	Discussion	Sean Solomon
12:00	Lunch	
1:00	Analysis Group Reports <ul style="list-style-type: none"> • VEXAG <ul style="list-style-type: none"> ○ Venus “Goals” Document ○ Venus STDT ○ Next VEXAG Chair • LEAG <ul style="list-style-type: none"> ○ Update on FEAT ○ Update on LAT 2 (if possible) • MEPAG <ul style="list-style-type: none"> ○ MSL (if not covered previously) • OPAG • Discussion of formation of SBAG • CAPTEM 	Janet Luhmann Clive Neal Vicky Hamilton Hal Weaver Hal Weaver Chip Shearer
3:30	Q&A with the AA	Alan Stern
4:30	Discussion, Formulation of Recommendations, Planning of Future Meetings	Sean Solomon
5:30	Adjourn	