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Planetary Science Subcommittee
of the
NASA Advisory Council

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Meeting Minutes

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Table of Contents

| | |
|--------------------------------------|----|
| Welcome | 3 |
| Planetary Science Division Status | 3 |
| Mars Exploration Program Status | 5 |
| MSL | 5 |
| Q&A with Dr. Weiler | 7 |
| AG reports | |
| VeXAG | 8 |
| LEAG | 9 |
| MEPAG | 9 |
| Mars Future Program Planning | 10 |
| Annual Ethics Briefing | 11 |
| OPAG Status | 11 |
| SBAG Status | 12 |
| CAPTEM Status | 13 |
| GPRA grading exercise | 13 |
| Radioisotope Studies/Pu Availability | 13 |
| Discussion/Letter | 15 |
| MAVEN Mission | 15 |
| Deep Space Network Report | 16 |
| Report on Decadal Survey Planning | 16 |
| Discussion | 17 |

Appendix A- Agenda

Appendix B- Membership

Appendix C- Attendees

Appendix D- List of Presentations

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July 9, 2009

Welcome

Dr. Frances Bagenal, interim Chair of the Planetary Science Subcommittee (PSS) opened the meeting. Members introduced themselves and agenda items were briefly reviewed.

PSD Status

Dr. James Green, Director of the Planetary Science Division (PSD), recounted recent activities. The vacancy for Planetary Protection Officer (PPO) has been closed; a candidate has been selected for this position and will be announced soon. PSD is preparing to advertise for a new Astrobiology lead (position currently held by Dr. Mary Voytek). The Planetary Instrument Development PIDDP has been placed temporarily under Ms. Lisa May, due to the departure of Dr. Jon Rall. Dr. Natasha Johnson has departed for Goddard Space Flight Center (GSFC).

National Academies of Science (NAS) Studies

The Radioisotope Power System (RPS) and plutonium (Pu) availability studies are complete. A report on Planetary Protection measures for a Mars Sample Return (MSR) mission is now available on the NAS website. A midterm letter concerning a near-Earth object (NEO) study is expected by September. A study on role and scope of mission-enabling activities in the PSD Research and Analysis (R&A) program is moving toward completion. The Planetary Science Decadal Survey has begun, and the Stand-Alone Mission of Opportunity (SALMON) program has announced a selection of missions of opportunity: Strofio on Bepi-Colombo, and Lander Radio Science (LaRa) on ExoMars.

PSD Budget

The top line budget for NASA in FY10 is roughly \$18.7B. PSD and the Earth Science Division (ESD) budget outlays are comparable, with \$400M of stimulus money having gone to Earth Science. The PSD budget has increased slightly, but has evoked some changes. The Outer Planets (OP) flagship is now funded as a Europa-only mission, in its study phase; \$2.2B was considered inadequate for a Decadal Survey-level science mission. NASA is now moving ahead with the European Space Agency (ESA) to develop a more complete mission. The budgetary impact of the delay of the Mars Science Lander (MSL) is still under analysis. PSD has stipulated that every Mars launch opportunity be shared with ESA. The Lunar Robotics program has been transferred into PSD from the Exploration Systems Mission Directorate (ESMD) to help support International Lunar Network (ILN) studies. NEO stewardship has been passed from ESD to PSD. PSD will continue with missions in development, i.e. Juno, Gravity Recovery and Interior Laboratory (GRAIL), Mars Atmosphere and Volatile Evolution (MAVEN), Lunar Atmosphere and Dust Environment Explorer (LADEE) and ILN, and will continue to fund operating missions. The New Frontiers-3 Announcement of Opportunity (AO) has been released.

The Decadal Survey will be delivered in January 2011, when the preparation of the FY13 budget is underway. Dr. Green emphasized that the Survey panel will have to work hard to accommodate the new budget, adding that the FY11 budget will be the first time the new Administration can leave its mark on any future direction. While it is recognized that considerable resources have gone into ESMD, there have also been deeper cuts throughout the Science Mission Directorate (SMD).

Compounding the budgetary problem is access to space; there will be extremely high launch costs associated with planetary missions. This is a critical issue for the next decade and it holds the potential to erode buying power for future missions. NASA may be able to procure a limited number of Falcon and Taurus (medium-class) vehicles, and perhaps rely on some international launches. Mr. Doug McCuisition added that NASA also has a certification process for each new launch vehicle, which must be as expeditious as possible. Dr. Green pointed out that LADEE would be launching on a Minotaur (\$40-50M), a gap filler vehicle. Asked if there were any possibility of separating launch from mission costs, Dr. Green replied that the New Frontiers and Discovery programs utilize this separation, with a cost cap on the mission only, but that the net effect will still be a reduced launch rate due to the distribution of funds. Dr. Slavin commented that the market for larger vehicles is shaped by the Department of Defense (DOD) and commercial needs. NASA will need a market to emerge for smaller and medium-class launch vehicles in order to take advantage of competition. Dr. Bagenal suggested that PSD might do well to "bulk-buy" a series of launchers, representing a fiscal reason to rely on a strategic plan.

Missions

The Mercury Surface and Space Environment Geochemistry and Ranging (MESSENGER) mission is preparing for its third flyby in September. Venus Express has been extended to the November/December timeframe and is doing well. The EPOXI mission, a reuse of the existing Deep Impact spacecraft, is on its way to comet Hartley 2. ESA's ROSETTA mission is in deep hibernation, and JAXA's Hayabusa is returning with its sample. The Dawn spacecraft completed a gravity assist on its way to the asteroids Vesta and Ceres. Juno has just completed major milestones and a critical design review (CDR), and is on track in terms of schedule and cost. Late this decade, NASA will be working on an Outer Planets flagship (OPF) with ESA. The Cassini Extended Mission will be completed in July 2010, and the New Horizons spacecraft is on its way to Pluto. The Mars Phoenix lander completed its mission in November. The Opportunity rover is making progress toward the Endeavor crater on the Mars surface, while Spirit remains immobile. Mars Express has been extended by ESA into November. The Mars Reconnaissance Orbiter (MRO) is functioning well and the MAVEN mission is progressing. The Mars Architecture is currently under revision. The Moon Mineral Mapper (MMM), a NASA instrument on India's Chandrayaan craft, has begun to submit papers to *Science*. The Lunar Reconnaissance Orbiter (LRO) will be transferred to PSD after its first year of operation. The Heliophysics Division (HPD) is using two of its Themis spacecraft to study solar wind interaction with the Moon, as well as shock and plasma structures, and will be a good complement to LADEE. GRAIL, a Discovery mission, will be launched in 2011.

Opportunities in New Frontiers and Discovery

The third New Frontiers AO has been released and has received 8 notices of intent. The AO is an open competition for Principal Investigator (PI)-class missions of strategic importance in the \$1B class. Proposals are due July 31, 2009. Asked if this AO would be influenced by any ESA missions, Dr. Green cited the Ganymede Observer, and possibly LaPlace. Discovery-12 announcements for medium missions will be open to all objects except the Sun and Earth. The cost cap is \$425M, excluding the cost of the launch vehicle. PSD expects to select 2-3 candidates for 9-month phase A studies before a final downselect, with a launch planned for no later than December 31, 2016. A draft AO will be available in July or August and final AO in November/December 2009. In response to PSD concerns about schedule, Dr. Green noted that SMD Associate Administrator Dr. Ed Weiler has stated to Congress that the AO will go out by the end of the year. Dr. Bagenal felt that with the lack of funding, going through the exercise of writing the proposal might represent a waste of time and energy within the community.

Dr. Green commented that Dr. Weiler, as selection official, would make decisions according to budget reality.

Advanced Stirling Radioisotope Generator (ASRG) update

Two ASRG flight units are scheduled to be delivered in 2014. The units have a 14-year nominal lifetime and 30% efficiency. The PSD Mission roadmap demand for Pu-238 exceeds available Pu-238 and the new Pu-238 production rate therefore planned missions will have to be reconciled with available supply. A fair amount of Pu is being set aside for Outer Planet missions. In the FY10 budget, the Department of Energy (DOE) has allotted \$30M to begin a preliminary design and engineering plan to domestically produce Pu-238; several more years of more funding, however, will be required to reestablish Pu-238 production capabilities. NASA is not contributing funds toward production and is planning to purchase Pu from DOE. NASA missions, and other unspecified agencies will be the consumers of this supply: NASA is targeted for 5 kg Pu per year.

Outer Planets Flagship missions

Cassini continues to operate in its extended Equinox mission, with tentative plans for a Solstice mission; a decision is expected after the President's budget announcement in 2011. The extension would cost \$65M per year in mission operations. PSD is working with ESA to increase the interdisciplinary scientist budget, which heretofore has been confined to the Huygens portion of the mission. The Jupiter Europa Orbiter program is working hard on getting schedules aligned with ESA. ESA is now in the process of downselection from 3 to 2 missions: LaPlace (Ganymede orbit), EXO (x-ray mission), and LISA (gravitational wave), to be announced in 2010/11, with a final, single selection in 2013. The goal is to release a joint AO with ESA for instruments, with agencies able to propose for instruments on either mission. Missions of opportunity through SALMON are soon to be released for instruments on the Ganymede Orbiter, and these will be evaluated jointly. If LaPlace is not selected, NASA will continue with its plans for the most technically feasible Europa Orbiter. A possible joint JAXA/NASA mission is still under consideration. Dr. Green noted PSD concerns about mission budget, ESA/NASA schedule mismatches, and radiation risk mitigation, and offered a briefing on NASA's recent Instrument and Radiation workshop for presentation at the next subcommittee meeting.

Planetary R&A Overview

PSD has restored funding to R&A, and will continue funding on an inflationary path. Dr. Green noted that PSD has NEO back in the R&A budget, with a goal of discovering 90% of NEOs greater than 1 kilometer in size within 10 years (1998-2008). NEO has limited assets and PSD will continue to seek partners in order to carry out its mandated task. Thus far, the program has achieved its minimum goal at the 1-kilometer level (864 of an estimated 940-1050). Many objects 140 meters and larger have also been found.

Mars Exploration Program Status

Mr. Doug McCuiston presented the Mars program status, and reported that the Mars Odyssey satellite is doing well, having had a new communication architecture established with MRO. An attempt will be made to move Spirit within the next several weeks. MRO has finished its prime mission and fulfilled all Level 1 requirements. The program is considering an additional landing site for MSL, and will attempt to communicate with the presumably frozen Phoenix in October/November.

MSL Status

MSL was given a new baseline in May. An Agency Program Management Council (APMC) was held on 18 June to determine budget reserves. The APMC approved MSL for continuation, knowing that current reserves are low at 13%, additional challenges remain, and that additional reserves may be necessary. Significant changes have been made. A new Project Manager has restructured the project, with the addition of a new integrated systems engineering program, which has been assessing the entire technical system. Engineering Model/Testbed work has been increased to further reduce risks.

Extensive testing is being performed on actuators, focusing on anomaly resolution, life test completion, and flight unit production. The 100 and 200 series flight units are done and in-house. The 300 series actuators still have bearing and motor issues, and engineers are seeking the root cause of thermal backdrive torque and bistability problems. There are also some field-programmable gate-array (FPGA) problems in the avionics systems, and flight software as a result.

Many items in the integrated system have been completed. The largest portion of work is left in the rover itself. A new issue is surface power, as demands are much higher than predicted (RTG is one issue). Actuators will need to be heated. The Sample Analysis at Mars (SAM) instrument is consuming more than twice its power level requirement; the problem is being worked through operational sequences. The key factor appears to be wide range pump requirements; mitigation include varying run times and intervals. A new set of batteries may provide 80-90% of the power. There is concern about the life test of the wide-range pumps, and the instrument must also complete an environmental qualification program.

MSL launch period options

The launch queue preceding MSL is still quite full. If the Juno mission slips, MSL will be bumped into a Type 1 configuration, which has implications for the communication coverage for entry, descent and landing (EDL), mostly in terms of latency and redundancy.

The funding shortfall is expected to be between \$15-115M more. The amount will be determined this calendar year after technical issues have been addressed. The impact of the cost must remain within PSD. To do this, a plan has been outlined, in order of implementation:

- Reduce or eliminate Mars Program APA (Headquarters reserve monies) in 2010 and 11,
- Reduce US portion of Mars missions in 2016/2018/2020,
- Reduce Discovery future and New Frontiers mission lines (no impact to current schedules).

If the cost impact is in the upper range;

- Further reduce US portion of missions in 2016/2018/2020,
- Delay LADEE and ILN,
- Delay NF3 phase B selection.

A breach report for MSL will be submitted to Congress by the end of July. Headquarters and SMD will continue tracking the mission's progress through detailed meetings and metrics. A Readiness to Proceed Review will be conducted in November 2009, at which time all previously noted technical issues must be stabilized, and an independent cost estimate (ICE) will have been provided. After Readiness to Proceed, the program will then assess the need for additional reserves, which will require APMC approval, after which it will be brought back to PSS for review. The impact of the overrun will be known by the second quarter of FY10.

PSS urged that lessons learned from MSL be applied to Mars Sample Return.

Q&A with SMD AA

Dr. Weiler and the subcommittee discussed how to address the MSL issue and future directions for PSD. Dr. Weiler attributed some disappointments to excessive fiscal optimism in the previous Decadal Survey. He also reported another favorable meeting with ESA's David Southwood, which has resulted in plans for developing a high-level Mars Architecture team on the international level. The Decadal Survey's community has been assured that NASA is not attempting to end-run its conclusions, but Dr. Weiler reiterated the gravity of the budget numbers; as a result, the New Frontiers and Discovery lines, and Moon and Mars missions, constitute the trade space. Mars Sample Return must be an international effort, NASA cannot do it alone. He added that a Europa/Ganymede mission continues as a cooperative effort between ESA and NASA.

Regarding MSL, Dr. Weiler looked to PSS for ideas on how to deal with limited funds, including consideration of cancellation, and recommended that scientists speak out on the noncompetitive aspects of the lunar program. However, the fact remains that SMD must make tough decisions based on competitive peer review and NAS studies. He suggested PSS remain actively involved in formulating a Mars joint architecture with ESA, long before the team is convened, and to advise Dr. Green as PSS sees fit. He reminded the subcommittee that if MSL is continued, Dr. Green would have to make tactical decisions to conserve money; in the worst-case scenario, this would entail cancelling a New Frontiers mission, delaying LADEE, and cancelling ILN. He asked PSS to continue its guidance on scientific priorities for tough advice in the light of real problems, and to consider the fiscal benefits of a NASA/ESA collaboration. Even if MSL had not overrun, PSD would still have an inadequate budget for a Europa mission. Asked for reassurance about the cost realism in the new Decadal Survey, Dr. Weiler noted that independent cost estimates will be incorporated into the Survey; these cost estimates will be provided on both the NASA and Survey sides. NASA has also informed the Survey committee that it can only accept two priority-one missions. It is hoped that the initial cost estimates will provide about a 50% margin for missions.

With regard to launch vehicle costs, Dr. Weiler held the view that NASA is at the mercy of the commercial market, i.e. Falcon 9 and Taurus 2, and that its salvation would be competition, as PSD tends to launch more small and medium-sized missions. In response to a question as to whether MSR might be converted to an in situ mission, Dr. Jack Mustard averred that the science return from a well-done MSR would be several orders of magnitude better than an in situ mission for the significant science questions that have already been identified. He offered the lunar analogy by way of illustration.

Asked about the soonest scenario for MSR, Dr. Weiler felt it would be in the 2022/24 timeframe, or more realistically, 2024/28, at an optimistic cost of \$6-8B. Dr. Green added that PSD would need to work MSL off the books before MSR could be addressed. Dr. Weiler noted that MSR technology development may not get done within the foreseeable Mars budget. NASA and ESA each have about 70% of the budget for MSR; by opening up to a broader architecture out to 2020, the two agencies can spread the capabilities over several opportunities. However, NASA cannot afford to lead every Mars mission. ESA is interested in developing EDL technologies. While there are no preexisting commitments NASA had in 2016 for ESA, there

are some natural areas in telecommunications for the 2016 opportunity. Dr. Green reiterated that both agencies have compromised and agreed to a notional plan, which must be followed by further technical analysis, and that furthermore, international cooperation is critical. The current atmosphere is far better than it was last year, including breaking ground on solving ITAR issues. Dr. Weiler noted that while NASA and ESA are the natural leaders in this respect in terms of setting the framework, other countries can then come to the table. Dr. Green added that the community should take advantage of the regular bilateral meetings, and Dr. Bagenal recommended the Analysis Groups (AGs) as good sources for planning and collaborative development. Within the ILN effort, Dr. Green noted 9 space agencies have signed a statement of intent to coordinate some aspect of their observations, and are working up a list of core instruments for correlative work. Dr. Weiler reiterated for the record that the Planetary program is run by the PSS — PSD will not make any decisions to delay or cancel any missions without advice from the PSS. Real content cuts or dramatic changes must be made by the community.

Discussion

The subcommittee briefly discussed items of administration and potential findings. The previous recommendations were distributed as a reference point for current recommendations. Dr. Bagenal announced that she had appointed an interim vice chair, Dr. Mustard.

VEXAG Status Update

Acting Venus Exploration Analysis Group (VEXAG) co-chair Dr. Sanjay Limaye gave an update on recent activities, including preparation of Venus white papers for Decadal Survey input, international Venus exploration activities, comparative planetology studies, and the ESLAB conference on Venus-Earth-Mars in May 2009.

Dr. Limaye reviewed various white papers covering such subjects as astrobiology, technologies for Venus exploration, Venus atmosphere, etc. All inputs will be available to the Decadal Survey Sub-panel by mid-September 2009. A VEXAG community white paper has been revised recently to include a split-off technology section. This section contains all the key technologies required for Venus exploration, compiled from various contributing reports. A baseline mission concept has been identified, comprised of a multi-element mission architecture, two cloud levels (current concept is 55 km altitude), balloons, two landers and a science/telecommunications orbiter. These reports can be accessed at vfm.jpl.nasa.gov. Additional mission concepts are being solicited from the community. International efforts include a JAXA mission, Venus Climate Orbiter (VCO), is due to launch in May 2010. The European Venus Explorer (EVE) to be re-proposed in 2010, and Russia is planning the Venera-D mission.

The Venus Flagship mission study has been completed, and New Frontiers and Discovery proposals are in the planning stages. A Low-Cost Planetary Missions Conference is being hosted in India (IAA) from August 31st- September 4th (abstract deadline is July 15). Space agency representatives have been invited to present plans for planetary missions. The aim of the conference is to create new collaborations to make up for the loss of opportunities that have occurred between recent Venus orbiters. Current spacecraft are tone-deaf to one another; this situation could have been eliminated by planning. A Comparative Planetary Climatology Focus Group has been convened to seek input from various communities to plan a series of workshop or a conference on the subject.

The Venus Science and Technology Development Team (STDT) has issued recommendations on technology and instruments for future Venus missions, including concepts for designing a sample acquisition and handling system, lander design, long-lived seismology and metrology, humans in the loop lander missions, and near-surface aerial mobility (both refrigerated and nonrefrigerated options).

The next VEXAG meeting will be held October 28th-29th, 2009 in Irvine, CA. Dr. Bagenal requested a short summary of the meeting results via email.

LEAG

Dr. Clive Neal presented results of the Lunar Exploration Analysis Group (LEAG). The Lunar Reconnaissance Orbiter Camera Special Action Team (LROC-SAT) has reviewed and commented on numerous regions of the Moon; its report was delivered to the Constellation group on May 14th. The team reviewed gaps in the program, such as unsampled geochemical terrains and unrepresented midlatitude sites. The next Mission Town Hall meeting will gauge the community as to what should happen next on the moon. Sample return from Aitken basin is still a high priority, as are visits to the lunar poles, Nectaris Basin sample return, Aristarchus plateau exploration and sample return (long-range rovers, in situ age-dating, hoppers with km-range instead of rovers). No prioritization of notional missions has been performed. LEAG also reviewed the potential for SMD-ESMD joint missions, considering an in-situ resource utilization (ISRU) technology demonstration, lunar dust toxicity, lunar magnetic anomalies, and commercial opportunities. A Lunar Science Forum will be held July 20th-23rd as a special session to gather input for the Decadal Survey, and it will include plenary talks and breakout sessions, and white papers on ILN, South Pole-Aitken (SPA), lunar poles and other high-science priorities. A Surface Scenario SAT was held with the Optimizing Science and Exploration Working Group (OSEWG) at Goddard Space Flight Center in May; its report will be transmitted to OSEWG, and will be available on LEAG web site.

The Lunar Exploration Roadmap is being finalized and has become an integrated document over different time phases. The LEAG annual meeting will be at the Lunar Planning Institute (LPI) in Houston November 16rd -19th, and will complete the Sustainability theme, incorporating results from LCROSS and LRO by that time. OSEWG/LEAG will hold a Round 2 meeting the first week in August.

MEPAG

Dr. Jack Mustard provided an update on the Mars Exploration Program Analysis Group (MEPAG), beginning with recent science results from Phoenix. The Mars ice table was found almost exactly as predicted by orbital data and theory (4-5 cm). One surprise however was the identification of uniformly distributed, very hygroscopic perchlorates, which may prove to be a global phenomenon. Carbonates were found in abundances of 3-5 weight-percent, detected by both the TEGA and MECA instruments. Mars chemistry appears to be buffered by carbonate, resulting in an alkaline soil pH. These are interesting results with broad implications. Recent developments include the renaming of the MSL mission to Curiosity. A MEPAG meeting was held in March 2009 as a kickoff event for Decadal Survey preparation activities, and for architecture planning for the next decade.

In preparing for the Survey, MEPAG is striving to be inclusive of the broad community and to address the larger themes represented by the Decadal Survey. Important dates for input can be found at: mepag.jpl.nasa.gov/decadal/index.html#portal.

Dr. Mustard briefly reviewed the two categories of papers. MEPAG will be coordinating one category, and a community level group will be coordinating the other. MEPAG papers will cover such subjects as Science Overview, Science Goals, State of Knowledge of Mars Science and Next Decade Objectives. In addition, MEPAG papers will address technology development needed for 2011-2020; mid-range rover options for the 2018 timeframe and how they might relate to sample return; geophysical network; Mars sample return overview; and the incorporation of a Mars Science Orbiter SAG (science analysis group) report. Community-identified papers include Mars polar science, atmospheric science, landing site characterization and selection, Mars crustal magnetism and dynamo history, in-situ geochronology, investigation of interior of Mars, and astrobiology. There has been some discussion on getting the community together to speak with one voice, incorporating as many opinions as possible without deluging the Decadal Survey.

New activities of the MEPAG include the creation of the 2016 Joint Instrument Definition Team (JIDT). This team was convened at NASA request to consider a scaled-down MSO mission focused on trace gases. The JIDT is studying options for a joint orbiter that would deploy ExoMars from orbit. Dr. Bagenal asked: if ExoMars were to be delayed to 2018 along with an MSL overrun, when would this MSO concept be funded? Dr. Zurek responded that a joint AO would come out in FY11. Dr. Mustard protested that such a mission would be overly cost-constrained. Dr. Zurek presented some scenarios that might arise in such cases. Dr. Green cautioned against misunderstanding; PSD is trying to determine the best science, and how it is implemented will be constrained by the budgets of both NASA and ESA. Regardless of outcome, it would be wise to have a definition team to move forward and delineate the science. Dr. Mustard agreed that the path is moving but that the science remains strong. The mission cost is estimated at \$850- 1B.

A Mid-Range Rover SAG is considering a mission concept with fundamental in situ science, sample caching capability, etc. A Network SAG is evaluating and assessing science priorities for a geophysical network. MATT-3 is the preferred architecture- while dates may have shifted to the right, the order remains the same in order to build on developing technologies.

MEPAG recognizes that expanding the international scope of Mars activities is becoming more important, and has welcomed international scientists to the MEPAG Executive Committee and to other subgroups of the MEPAG. The Mars Climate Center has been put aside temporarily but will be re-addressed this month. Dr. Bagenal asked if lessons from Phoenix were being incorporated for the Scout program. Dr. Mustard responded that this could be built as a MEPAG task. Dr. Bagenal recommended that science prioritization, technical and program implementation lessons from Phoenix should be considered by MEPAG and reported back in November. Dr. Zurek added that the Discovery option is new and should also be considered by MEPAG.

Mars Future Program Planning

Mr. McCuiston distributed a press release on the NASA/ESA integrated initiative described by Dr. Weiler in the Q&A session (release can be accessed at <http://www.marstoday.com/news/viewpr.html?pid=28684>). Asked if there had been any discussion of Congressional approval, Mr. McCuiston noted that there would be extensive dialogue with Office of Management and Budget (OMB) and Capitol Hill over the interdependencies between agencies.

Joint studies for an international Mars mission began in January 2009, with the creation of a joint ESA-NASA Engineering Working Group, Joint Instrument Development Team (JIDT), and a Joint Executive Board composed of senior ESA and NASA managers. The lander's mass has been an obstacle, as it must incorporate roving, landing, drilling, and exobiology capabilities according to ESA demands. Study principles have been published on both sides, and while the agencies are working through the discrepancies, most goals are aligned. These include leading elements for future architecture. Science interests and requirements are uniquely aligned between US and ESA. The joint team is considering Trace Gas and Telecommunications Orbiter, Rovers, Geophysical Surface Science, and Mars Sample Return. In a future meeting, Mr. McCuiston planned to present iMars activities, and also a cost-validity analysis of MSR, as the error bars have shrunk in the latter case. NASA's first principle in science prioritization is to align the joint mission NASA/MEP/NRC as well as ESA goals. Dr. Zurek assured the PSS that the elements were well aligned with US interests. Mr. McCuiston noted that the payload on ExoMars is more like an Astrobiology Field Laboratory (AFL) than previously considered, as it is very focused on exobiology goals. The agreement across the agency is that it is focused on astrobiology. A follow-up concept on methane discovery remains a high priority. NASA and ESA are studying the 16/18/20 timeframe with a goal of MSR in the early- to mid-2020s. Completion of the ExoMars mission is an important ESA priority. Initial studies should be available in late July/early August of this year.

Dr. Bagenal felt a bit uneasy at implementing the international effort simultaneously with the new Decadal survey just under way. Mr. McCuiston remarked that the NRC Mars Astrobiology report can serve as input to the Survey, and that any dual-agency adjustments can be made over time. He did not feel that the ESA criteria would change. Dr. Steve Squyres commented that the Decadal Survey Steering Committee is expected to articulate the opinion of the community and that it is unlikely there will be a big mismatch. He agreed, however, that Mars planning would be much harder to fit into the entire planetary portfolio.

A MART (Mars Architecture Review Team) was established in 2007 for independent guidance. MART functions as a Standing Review Board (SRB) at a program level. Findings to date are focused on the US accommodation of the current ExoMars mission on the 2016 NASA orbiter mission, and the follow-on 2018 opportunity. The astrobiology focus is well supported by the suite of missions and the 2016 trace gas/methane orbiter is a high priority for later landers. MART has concluded that a 1200-kg lander is unrealistic for 2016; 2018 is the best energetic opportunity for this mass. The plan is to internationalize MART to support the ESA/NASA Mars joint initiative. MART is currently seeking a chair.

Annual Ethics Briefing

Ms. Rebecca Gilchrist delivered the annual ethics briefing for Special Government Employees.

OPAG

Dr. Bill McKinnon presented the recent activities of the Outer Planets Analysis Group (OPAG). Two major issues have arisen from 9 official findings, many of which are related to budgetary pressures. The OP community applauded the announced prioritization of the OP Flagship sequence, with the Europa Jupiter System Mission first, while recognizing that work remains to be done in coordination and reduction of technical and cost risks. The second critical issue recognized by OPAG was input to the Decadal Survey; OPAG is working on submitting a consensus white paper.

The OPAG vigorously encouraged NASA to continue preparations for the NASA side of the international Outer Planet Flagship mission, including reduction of radiation risk and continuing instrument development, while continuing scientific input into the process. OPAG endorses the scientific pyramid approach as articulated by R. Greeley. OPAG also strongly endorses the concept of a sequence of Flagship missions to the Outer Solar System, and an Outer Planets Program at NASA that can retire the technical risk associated with a major mission to Titan (which may include aerocapture), as well as to maintain a science working group to provide advice and input to such a program.

OPAG strongly endorsed keeping Juno on its current schedule and to mitigate any potential delay to the mission, should circumstances arise. Dr. Green reported in this context that PSD has changed the Headquarters-held reserve posture for Juno in order to take advantage of software development in the next few years. If Juno runs into a \$57M problem in 2011, however, it would slip. If Juno needed money in 2010, however, the program would use their \$26M of reserves.

OPAG recommended that NASA evaluate a new mission class — Small Flagship missions — above New Frontiers, but less costly than a Flagship, to enable a great diversity of targets. A Small Flagship would be targeted at less than \$2B.

OPAG encouraged the community to craft their own white papers in addition to the OPAG white paper for submission to the Decadal Survey. OPAG also urged NASA to support usable mission studies.

OPAG encouraged all relevant federal agencies to explore innovative ways to make sufficient Pu available for future OP missions, and also commended NASA for making a power system available for a Discovery 12 mission.

OPAG endorsed the Cassini Extended Mission while recognizing need for training the next generation. Dr. Bagenal suggested that PSS recommend facilitating the procedure at the Agency level to create a co-investigator slot to accommodate young investigators.

OPAG suggested that Planetary Data System (PDS) improve its capability for archiving and retrieval, for more usable data. Dr. Green noted that there are plans under way to improve PDS that have not yet been presented to PSS.

Finally, OPAG emphasized that NASA capabilities for communication with the Outer Solar System should not be allowed to atrophy or disappear entirely.

SBAG

Dr. Hal Weaver presented the results of the Small Bodies Assessment Group (SBAG), reporting that former Chair Dr. Faith Vilas had resigned to serve as National Research Council co-chair on an NEO study; Drs. Mark Sykes and Hal Weaver are the new co-chairs. SBAG has held its inaugural workshop and has begun work on an SBAG Strategy Document. Minutes and findings can be found at: www.lpi.usra.edu/sbag. SBAG's areas of interest are small bodies science, missions, sample return, remote sensing, etc.; while the group highly values New Frontiers-class missions, it also supports Flagship missions, particularly a cryogenic comet sample return, focusing on technology development. SBAG is also considering targets of opportunity, such as

taking advantage of fly-bys in the asteroid belt with serendipitous science. SBAG supported the NASA decision to host the next IPEWG meeting to promote international cooperation, and Earth observation of small bodies. Dr. Green added that the charge to the Decadal Survey would include the cooperation of the National Science Foundation (NSF) in its role for observing small bodies from Earth. SBAG supported strong R&A funding and expansion of the PDS to accommodate new data, and the maintenance of the Deep Space Network.

SBAG will be supporting Decadal Survey input via Dr. Mark Sykes, who will coordinate community input through the website. SBAG will also hold a two-hour community workshop at DPS 2009. SBAG will play a role in supporting the Primitive Bodies Decadal Survey, and is expecting contributory white papers to be submitted by September 4th.

CAPTEM

Dr. Meenakshi Wadhwa presented the status of the Curation and Analysis Planning Team for Extraterrestrial Materials (CAPTEM), whose primary role is to allocate NASA-collected samples to the broader scientific community. CAPTEM also oversees sample preservation and curation, including samples from the Apollo program, Genesis, cosmic dust, and Stardust. Future issues for CAPTEM are providing input to the Decadal Survey, initiation of an independent review of Stardust samples, and addressing a recent increase in demand for lunar samples in anticipation of future lunar exploration. CAPTEM will use OSEWG to interface with ESMD to complete the latter task. CAPTEM is preparing white papers for technologies for sample return and curation, including sample return from Mars, asteroids, comets, and the Moon. Drafts will be posted by mid-August on the CAPTEM website. New initiatives under consideration for CAPTEM are tying sample science to latest orbital data from Mars and Moon; involvement in sample curation in international missions (Hayabusa, e.g.); and the planning of MSR with greater international cooperation.

GPRA

Philippe Crane led the discussion on grading PSD according to the Government Performance and Results Act (GPRA) and reviewed suggested highlights that support the accomplishment of the stated goals. PSD reviewed science outcomes 3C1 through 3C4 and voted unanimously on a Green grade for each.

July 10, 2009

Dr. Bagenal opened the meeting with a recommendation that PSD outputs be made available on the LEAG and NRC websites.

Radioisotope Power Systems

Dr. Ralph McNutt, co-chair of the Radioisotope Power Systems (RPS) Committee of the Space Studies Board (SSB)/Aeronautics and Space Engineering Board. He reported already having briefed this information to several venues. The committee was well represented in engineering, science, DOD and NASA representatives. The statement of task was to address the technical readiness of the US to create radioisotopic power systems and strategies for re-establishing Pu-238 domestic production. The Committee's report was delivered in April 2009 and has been on the web since May.

The Committee's task was undertaken in the context that space exploration is still considered important as a national goal, RPS is vital to US space exploration, Pu-238 is the only viable fuel

for RPS instruments, and Pu-238 is not being manufactured anywhere in the world at present. NASA will soon use up its supply, therefore meeting NASA's future needs requires immediate action by DOE and timely development and flight testing of advanced radioisotope systems by both DOE and NASA in partnership. RPS units are vital for sunless exploration and for multi-year mission power supplies. The goal is to produce ASRGs (Advanced Stirling Radioisotope Generators) which have not yet been operated in space. ASRGs are much more efficient than older radioisotopic power system designs (24% vs. 6%), but there are still questions about their reliability; their moving parts constitute a risk factor.

The Committee found that RPS's have been and will continue to be essential to US science and exploration. Dr. McNutt noted that Pu-238 cannot be used in nuclear weapons (atomic weapons use Pu-239). With respect to the supply, the Committee found that Pu-238 is the most suitable fuel as a function of its half-life, emissions, and power density. Pu-238's principal decay mode is alpha, with some weak gamma emission, and it has not been produced in the US since reactors were shut down in the late 1980s. The report's finding on nuclear safety concludes that while the current US flight safety and review and launch approval process does address public safety, the process introduces schedule requirements that must be considered when using RPS in a mission. The current process cannot be sped up, thus missions using these systems must incorporate planning very early in the process, in order to obtain the necessary permissions from multiple sources. Relying on other fuels or radioisotopic concepts will increase risk substantially and delay production levels. Commercial light water reactors are a long-term solution, possibly, but would take 15-20 years to develop. There is no commercial market for Pu-238.

In the Committee's judgment, NASA has already been making mission-limiting decisions based on the short supply of Pu-238. For future demand, the NASA Administrator recently sent a letter to DOE with an estimate of NASA's future demand for Pu-238, to be used as a conservative point of reference for determining future NASA needs. As envisioned, the current plan is to produce Pu-238 for the period 2009-2028, to cover missions including MSL; Discovery 12, an OP Flagship baselined with MMRTGs, and lunar pressurized rovers. The total demand for NASA is expected to be about 5.3-5.5 kg/year, on average. The best case estimate, even if the DOE budget for 2010 includes funds for reestablishing production, is that NASA will still suffer a shortfall. Continued delays will only increase this shortfall. An OP flagship mission requires 20 kg of Pu-238.

DOE now has \$30M to reestablish plutonium production for the proposed FY10 budget. Programmatic balance is not possible, but NASA is moving the ASRG forward appropriately, at the expense of other technologies. The Committee recommended that NASA continue to develop multimission RTGs, and that the RPS program and mission planners jointly develop a set of flight ready requirements for RPS and ASRGs, as well as a plan and timetable for meeting the requirements. Dr. Green assured the PSS that the division is on top of planning these issues. The Committee also recommended that NASA develop a comprehensive RPS technology plan to meet mission requirements while using minimal plutonium supplies, to document and archive, and to plan for maturing technology while assessing and mitigating technical and schedule risk. Dr. McNutt noted the diminishing population of US citizens and US centers who have this knowledge as a very critical issue. Dr. Neal reported that DOE is establishing a center to perpetuate this knowledge base, and NASA might do well to leverage this effort.

The Committee issued a high-priority recommendation on ASRG development; *i.e.*, NASA and DOE must complete ASRGs with all due speed, and should life test them for at least two years, as soon as possible, perhaps on a Discovery 12 mission. Dr. Green agreed that while work is yet to be done, the MMRTG production line is safe, ensuring that the OP Flagship will be successful. He doubted an ASRG would be ready for OPF, however.

Based on budget and infrastructure, the hope is reach 5 kg production per year about 7 years from now. Dr. McNutt concluded by asserting that plutonium production is essential to US space exploration. Pu-238 will run out by 2020 without new production, therefore need immediate action is necessary. NASA's future needs will not be met without timely concurrent completion of ASRG development and deployment. If this is not accomplished, some missions will not be feasible for a minimum of 20 years. Dr. Green informed PSD that the issue is on the radar screen for both DOE and NASA at the Administrator level. NASA has also worked with the OMB examiner on DOE, trying to delineate roles and responsibilities, and has been working on this problem actively for several years. Dr. Bagenal endorsed the report findings, but expressed concern that the Mars missions were not called out. Dr. McNutt felt that another relevant point was the necessity to think a decade ahead, as well as in terms of the decreasing budget. A meeting participant asked whether the two ASRGs for Discovery should they be considered for another mission. Dr. Green replied that his goal was to get ASRGs into space as soon as possible. The RPS Committee report is available at http://books.nap.edu/catalog.php?record_id=12653.

Discussion on letter

PSD discussed preliminary findings, including an endorsement of the RPS Committee's conclusions, while pointing up extra opportunities not brought out by report. The subcommittee reviewed the list of priorities affected by the MSL overrun. Dr. Green stated in this context that PSD will know by the third quarter of 2010 whether more money will be needed. Dr. Neal suggested PSS hold off on a finding until the MSL readiness review and MEPAG have weighed in with their respective conclusions. Dr. Slavin remarked that the real issue is how to distribute the pain, and that the Mars program will have to feel a disproportionate amount of this pain. PSS discussed the implications of cuts to the Mars program, notably delays in the start of phase A studies in the Discovery and New Frontiers selections, the potential loss of the Mars 2016 opportunity, and concerns about the management of over \$1B in mission funding. PSS concluded, however, that the prioritization as laid out by Dr. Green's presentation would be supported by the broader planetary community.— want to know if PSS agrees with prioritization of cuts as laid out on slide 11.

Mars Atmosphere and Volatile Evolution Mission (MAVEN) status

Dr. Bruce Jakosky reported on the status of the Mars Atmosphere and Volatile Evolution Mission (MAVEN), which will be focused on detecting the loss of gas to space at Mars. The MAVEN mission is scheduled to follow the launch of MSL. MAVEN will study aspects of both aeronomy and astrobiology, and is designed to evaluate the current state and composition of the Mars atmosphere and what controls it. The mission will measure the drivers, reservoirs and escape rates via 8 instruments measuring solar inputs, plasma processes, and neutral processes, some of these instruments will do double duty, and all of them are all based closely on instruments that have flown previously. The MAVEN science team includes Dr. Jakosky (PI), Dr. Robert Lin, Dr. Joe Grebowsky, and Dr. Janet Luhmann. GSFC is providing management, systems engineering, independent technical authority (ITA), safety, resource analysis and management of payload services. MAVEN has much MRO heritage in its spacecraft design.

The mission launch window opens November 18, 2013, and the spacecraft will fly on a Delta IV or Atlas V vehicle, on a 10-month ballistic cruise, with an 18-hour burn into a precessing orbit, 3 week checkout period, for a nominal one-Earth-year mission. Normal periapsis will be near 150 km, with five deep-dip campaigns at 125 km. MAVEN will provide coverage of all local solar time and most latitudes. MAVEN's place in the solar cycle, just after peak of solar cycle, will see solar storms impacting the planet. The mission members have been working as a team for 5 years and are currently in the risk reduction, phase B mode, focused activities on instruments and spacecraft. MAVEN will undergo a PDR in July 2010 and CDR in 2011. Because MSL will be completing its primary mission when it arrives, MAVEN will be the relay backup for MRO and Odyssey. The mission is currently on schedule, budget and track.

In response to a question, Dr. Jakosky explained that radio science had been omitted from the mission due to high cost for relatively little science payback. Dr. Limaye lamented the loss of coordination with other satellites due to the lack of a radio. Dr. Jakowsky responded that MAVEN is both cost- and science- constrained, and that mass, power, and data rate requirements would have required significant changes for a mission that included radio capability. The mission could be extended to 2023 (for a presumptive MSR), but extension options are limited by fuel.

DSN presentation

Dr. John Rush, Director of Systems Planning at NASA Space Communications Office, addressed the needs of the planetary science community as they relate to the evolution of communications systems at NASA. SCaN, the Agency's Space Communication and Navigation office, is working on a "go-to" architecture that will be in place by 2025, providing a unified network for both robotic and human missions with the highest technically and financially feasible data rates. The system is to be internationally interoperable, intended to provide communications to the lunar and Martian surface, and meet all commitments for mission customers. Goals and challenges include the uncertainty of timing and the nature of future requirements, scaling the network up and down as necessary, and supporting legacy missions as capabilities evolve. Current networks include a near-Earth network whose longest range spans from the Earth to the Moon. The Space Network provides tracking and data relay, with coverage to low-Earth orbit, and the Deep Space Network (DSN) provides coverage of the Solar System.

Key requirements for space communications are derived from planned missions; by 2025 it is hoped that the DSN will have optical communications, supporting destinations such as Mars at 100 Mbps to 1 Gbps data rates. Mars Sample Return is listed as a requirement, as well as Ka-band arraying at Mars. Dr. Bagenal encouraged Dr. Rush to work with PSS to add requirements in preparedness for 2015 New Horizons' flyby of Pluto, as well as for other missions to the Outer Solar System. Dr. Rush presented a notional SCaN Integrated Communication Architecture, with plans in 2025 for a Deep Space Optical Array in Earth Orbit. SCaN is currently adding optical terminals to the DSN, and is planning demonstrations to prove the utility of optical communications. Legacy radiofrequency (RF) communications capability will remain available.

Enhanced DSN Domain Capability

Ongoing support for DSN includes maintenance of RF ground centers. SCaN is currently evaluating how RF antennae will be replaced. An arrayed architecture of smaller antennae is under study as a replacement for the future decommission of the 70-m antenna; the array will undergo a one-year period of shadowing the original antenna. SCaN is also upgrading

transmitters as well as adding a new 34-m antenna to the Canberra site. Dr. Green asked how SCaN plans to retain a fundamental planetary capability (X-band). Dr. Rush replied that the arrays will retain this capability as requirement. Dr. Bagenal requested that a contact on the architecture team interface with PSS on future technical questions; James Adams was identified as this contact.

Report on the Planetary Science Decadal Study 2009-2011

Dr. Steve Squyres, Chair of the Planetary Science Decadal Survey (DS), outlined the Survey process as a conduit for extensive community input, stemming from an overview of current planetary knowledge, which will include interaction with the NSF. The second Planetary Science Decadal Survey will decide upon an appropriate mix of mission sizes, mission targets, and research activities. The Survey will consider both ground-based and space based planetary science, as well as astrobiology. There will be some overlap with astrophysical science in the consideration of extrasolar and giant planets. Dr. Squyres noted, importantly, that there is international membership on both the panels and steering committees.

The DS Steering Committee is composed of the Vice Chairs of Inner Planets, Outer Planets, Primitive Bodies, Mars, and Outer Planet Satellites panels, each panel having 10-11 members. The printed report is due to be released in the third quarter of 2011. This fall will be the area of peak activity for the panel, as they review white papers. The panels are specifically charged with producing a plan that is executable within the expected resources; this perspective will require a conservative picture of the costs, including ICEs funded by PSD. Missions of high interest will be brought to attention via the panels. The DS is relying on the Steering Group to make decisions using priorities that have been based on science and data from the various panels. Dr. Squyres reiterated that the Survey will be making no *a priori* assumptions of what the mix should look like. The final list will most definitely be constrained by cost, while simultaneously recognizing that international collaboration is enabling, especially in the OPF and the Mars program. The current thinking is that a baseline plan should include international partners, with explicit assumptions of what the Europeans would provide, as well as a credible "plan B" that excludes international participation. Funding assumptions are clear, based on the most recent budget and future projections.

Community interaction is being conducted via town hall and open meetings, outreach sessions, online communication, and webcasts. (It was pointed out here that SBAG needs to be invited to these meetings). Candidate missions will be considered with much more emphasis on technical maturity and probable costs. The first DS stated that MSL should have cost \$650M; the general consensus is that this figure was highly unrealistic. In response to concerns voiced by PSS, Dr. Squyres explained that if a mission has been extensively studied, the DS would not be inclined to commission further study, but there could be some aspect that might require further scrutiny (such as a cost risk in a technology). Dr. Slavin commented that until an STDT has been formed, a true cost estimate cannot be performed.

With respect to submission white papers, multiple authorship is encouraged. DS Panel Chairs and Steering Committee members are prohibited from submitting white papers. The community will decide how to assign costs for technology and development, in an attempt to assure fiscal and technical realism. Dr. Squyres used Solar Probe as a good example of re-scoping missions, and surmised that here may be a mission so risky as to require assessment by two independent organizations. Panel meetings will be open to the public as much as possible. Asked if Europa were being considered, Dr. Squyres reported that any mission that has a new start will not be

considered due to ties to future money. Dr. Bagenal urged the DS to avoid reinventing the wheel.

Discussion

The subcommittee discussed ways in which to transmit messages from SBAG to the DS Steering Committee, as well as making needs known for data archiving and availability. Dr. Weaver was assigned to write this finding. Other potential findings were identified: recommendations from OPAG, an endorsement of the RPS report and continued support of ASRG development and testing. PSS felt it was too soon to comment on DSN and planned to follow up with Dr. Adams again in November to convey PSS concerns and issues.

Dr. McKinnon was asked to provide a paragraph on PDS as it relates to OPAG, including supportive commentary for Flagship missions. Dr. Neal suggested that NASA expand its ILN plans to include ESA participation.

Dr. Bagenal requested all AG chairs to provide a paragraph summarizing the last 6 months of their respective activities, and specifically encouraged MEPAG to have an open discussion on which future Mars missions would be impacted by MSL. Dr. Slavin applauded the effort on internationalization of the Planetary Science program. PSS briefed Dr. Green on the preliminary findings, reiterating as a priority finding that NASA should not commit more funds to MSL until its readiness review has been completed.

Meeting dates were tentatively set for December 3-4, 2009, in Boulder, CO. Dr. Bagenal adjourned the meeting.

**Appendix A
Agenda
Planetary Science Subcommittee Meeting
9-10 July 2009
NASA Headquarters, Room 9H40**

9 July (8:00 AM – 5:30 PM)

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|-------|--|------------------------------|
| 8:00 | Welcome & Other Administrative Matters | Fran Bagenal, Michael New |
| 8:15 | PSD Update [1] [†] Including: 2010 Budget Status of Outer Planets Flagship Report on ESA-NASA Bilateral Meeting in late June Overview of Mars Architecture Review Team Current Status of MSL | Jim Green, Doug McCuiston |
| 10:00 | Break | |
| 10:30 | Q&A with the AA | Ed Weiler |
| 11:30 | Discussion | Fran Bagenal |
| 12:00 | Lunch | |
| 1:00 | Analysis Group & MOWG Reports • VExAG [2] • LEAG ^s [3] | Sanjay Limaye |
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NAC Planetary Science Subcommittee, July 9-10, 2009

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|------|--------------------------------|-----|--------------------------------|
| | • MEPAG | [4] | Clive Neal |
| | • OPAG | [5] | |
| | • SBAG | [6] | Jack Mustard |
| | • CAPTEM | [7] | Bill McKinnon [‡] |
| | | | Hal Weaver |
| | | | Mini Wadhwa |
| 3:00 | Annual Ethics Briefing | | Rebecca Gilchrist [*] |
| 4:00 | Evaluation of GPRA Metrics [8] | | Phillipe Crane |
| 5:30 | Recess for the day | | |
| | PSS dinner at <i>TBD</i> | | Fran Bagenal |

[§] This presentation will include a discussion of the Lunar Exploration Roadmap as well as the Augustine Commission.

[‡] Attending meeting by telephone.

^{*} Speaker not yet confirmed.

NAC Planetary Science Subcommittee, July 9-10, 2009

10 July (8:00 AM – 3:00PM)

| | | |
|-------|--|------------------------------|
| 8:00 | Welcome | Fran Bagenal, Michael New |
| 8:15 | Report on NRC Study of Plutonium Availability [9] | Ralph McNutt |
| 9:15 | Discussion | Fran Bagenal |
| 10:00 | Break | |
| 10:30 | Overview of the MAVEN mission [10] | Bruce Jakosky |
| 11:00 | Evolution of the Deep Space Network [11] | John Rush |
| 11:30 | Discussion | Fran Bagenal |
| 12:00 | Lunch | |
| 1:00 | Report on Planetary Science Decadal Study [12] | Steve Squyres |
| 2:00 | Discussion, Formulation of Recommendations, Scheduling of Next Meeting | Fran Bagenal |
| 3:00 | Adjourn | Fran Bagenal |

Appendix B Subcommittee Membership

Membership Roster

Planetary Science Subcommittee

Frances Bagenal, Acting Chair

University of Colorado, Boulder

James Bell III (pending member)

Cornell University

Lars Borg

Lawrence Livermore National Laboratory

Tom Cravens

University of Kansas

Caitlin Griffith

Department of Planetary Sciences

University of Arizona

William M. Grundy

Lowell Observatory

James Head

Department of Geological Sciences

Brown University

Gregory Herzog

Rutgers University

Kip V. Hodges

School of Earth and Space Exploration

Arizona State University

Jeffrey R. Johnson

US Geological Survey

Sanjay Limaye

Space and Science Engineering Center

University of Wisconsin

William B. McKinnon

Department of Earth and Planetary Sciences
Washington University

Robin Canup Mihran
Department of Space Studies
Southwest Research Institute

John F. Mustard
Department of Geological Sciences
Brown University

Clive R. Neal
Department of Civil Engineering and Geological Sciences
University of Notre Dame

Lisa M. Pratt
Department of Geological Sciences
Indiana University

James Slavin
NASA Goddard Space Flight Center

Dawn Y. Sumner (pending member)
Department of Geology
University of California, Davis

Meenakshi Wadhwa
Center for Meteorite Studies
Arizona State University

Hal Weaver
Space Department
Johns Hopkins Applied Physics Laboratory

Michael H. New, Executive Secretary
Planetary Science Division
NASA Headquarters, Washington, D.C.

Subcommittee Administrative Support:

Ms. Marian R. Norris

Management Support Specialist

Science Mission Directorate

NASA Headquarters, Washington, D.C.

Appendix C Attendees

Subcommittee Members

Frances Bagenal, Acting Chair, University of Colorado, Boulder

Thomas Cravens, University of Kansas

James Head, Brown University

Caitlin Griffith, University of Arizona

Will Grundy, Lowell Observatory

Jeffrey Johnson, US Geological Survey

Sanjay Limaye, University of Wisconsin

John Mustard, Brown University

Clive R. Neal, University of Notre Dame

James Slavin, NASA GSFC

Meenakshi Wadwa, Arizona State University

Hal Weaver, Johns Hopkins University/Applied Physics Laboratory

Michael New, Executive Secretary PSS, NASA HQ

NASA Attendees

Jim Adams, NASA HQ

Marc Allen, NASA HQ

Max Bernstein, NASA HQ, SMD

Robert Champion, OLIA, NASA HQ

Catharine Conley, NASA HQ

John Cooper, NASA GSFC

Philippe Crane, NASA HQ

T. Jens Feeley, NASA HQ

Chris Flaherty, OLIA, NASA HQ

Daniel Glavin, NASA GSFC

James Green, PSD, NASA HQ

Jennifer Kearns, NASA HQ

Lori Kearns, NASA HQ

Anne Kinney, GSFC

Doug McCuiston, NASA

Melissa McGrath, NASA MSFC

Michael New, NASA HQ

Marian Norris, NASA HQ

Ariana Ocampo, NASA HQ

Ramon P. de Paula, NASA HQ

Yvonne Pendleton, NASA ARC

Voleak Roehm, NASA HQ

John Rush, NASA SOMD

Eileen Stansberg, NASA JSC

Elizabeth Tuttle, NASA APL

Gregg Vane, NASA JPL

Michael Wargo, NASA ESMD

Nick White, NASA GSFC

Greg Williams, NASA HQ
Rich Zurek, NASA JPL

Other Attendees

Linda Billings, George Washington University
Jordan Bock, National Academy of Sciences, Space Studies Board
Randall Correll, Ball Aerospace
Dwayne Day, NRC
Lamont Di Biasi, Southwest Research Institute
Eric Hand, Nature
Mike Kaplan, Boeing Corp.
Ralph McNutt, Johns Hopkins University/APL
John Petheran, Lockheed Martin
Jaime Reyes, Lockheed Martin
Steve Squyres, Cornell University
Jon Weinberg, Ball Aerospace
Angie Wolfgang, National Academy of Sciences, NRC
Joan Zimmermann, Harris Corporation

Appendix D
List of Presentations

1. Planetary Science Division Update, *James Green*
2. Mars Exploration Program Status, *Douglas McCuistion*
3. VeXAG Status Update, *Sanjay Limaye*
4. LEAG Status Update, *Clive Neal*
5. MEPAG Status, *John Mustard*
6. OPAG Status, *Hal Weaver*
7. SBAG Status, *Hal Weaver*
8. CAPTEM Status, *Meenakshi Wadhwa*
9. Ethics Briefing for Special Government Employees, *Rebecca Gilchrist*
10. Report on NRC Study of Plutonium Availability, *Ralph McNutt*
11. Overview of the Mars MAVEN Mission, *Bruce Jakosky*
12. Space Communication and Navigation Overview and Status, *John Rush*
13. Report on the Planetary Science Decadal Survey, *Stephen Squyres*