National Aeronautics and Space Administration

Planetary Sciences Subcommittee

of the

NASA Advisory Council

March 3-4, 2008

Carnegie Institute

Washington, D.C.

Michael New	Sean Solomon
Executive Secretary Subcommittee	Chair, Planetary Sciences

Report prepared by Joan M. Zimmermann,

Harris Corporation

Table of Contents

Monday, March 3, 2008

Introduction

Planetary Sciences Subcommittee (PSS) Chair Sean Solomon opened the meeting and noted some transitions on the subcommittee, welcoming new members and thanking departing members.

Planetary Science Division Update

Director for the Planetary Science Division (PSD), James Green, reviewed administrative changes that had occurred over the previous 18 months, including significant challenges. Among the many issues that had been facing PSD at the start of that period were draconian cuts in Research and Analysis (R&A) and in Astrobiology, potential cancellation of the Juno mission due to increasing costs, potential cancellation of the entire New Frontiers program, politically driven transfer of the Near Earth Object (NEO) program, ill-defined lunar science activities, the failure to make a Discovery selection in response to the Discovery 2004 AO, no prospects for an Outer Planets (OP) flagship mission, and gross understaffing coupled with low morale. Dr. Green reported that these topics have largely been addressed in a successful manner, but there are a few additional challenges in PSD. He was pleased to report that the division has acquired new personnel and the welcomes the return of a former PSD Deputy Division Director from assignment as Acting Deputy Associate Administrator for Flight Programs.

Major fiscal year 2009 (FY09) budget changes include a $600M transfer from the Space Sciences to Earth Sciences over the next 5 years to support new Decadal Survey (DS) missions. Six new FY09 SMD missions are under way, including IceSat II and the Deformation, Ecosystem Structure and Dynamics of Ice (DESDynI) missions, Joint Dark Energy Mission (JDEM), Solar Probe Plus, an OP flagship mission, a lunar science orbiter, and budget increases in Astrophysics, Heliophysics, and Planetary Science R&A/Management Operations and Data Analysis (MO&DA). Budgets have been increased for suborbital programs and sounding rockets. Funding for new starts has been obtained from internal transfers, budgetary efficiencies, out-year mission opportunities savings, and a re-phasing of the Mars Scout mission, as well as the Heliophysics Magnetospheric Multiscale mission (MMS). The Deep Space Network (DSN) is being transferred to the Space Operations Mission Directorate (SOMD). Planetary Science is healthy and now possesses an increasing budget, relatively speaking.

Dr. Green reviewed the PSD budget line - the total Science Mission Directorate (SMD) budget is effectively $4.5B. Overhead money constitutes about $500M. The enacted budget for FY08 is $1.158B, with a large amount devoted to the Mars Science Lander (MSL) (30%). The proposed FY09 budget reflects about a $200M increase overall, with MSL amounting to 17%. This budget year will also see the lunar Gravity Recovery and Interior Laboratory (GRAIL) mission, and the Juno mission, moving into their developmental stages. A healthy R&A wedge remains at 15% of the budget. The lunar program will accommodate an orbiter and two landers, beginning roughly in 2010. Changes in the budget include the initiation of an OP flagship program, with the intent of executing regular flagship missions balanced between the inner and outer Solar System. Lunar science research has been augmented, as well as R&A. Other changes include Missions of Opportunity (MoOs) in the Discovery line, EPOXI (Deep Impact re-named) and a Stardust- NExT mission; a next-generation ion engine development program; a completed Stirling engine development program that is now in preparation for flight testing; the redirection of the Mars program to Mars Sample Return (MSR); and the expansion of U.S. participation in the European

Space Agency (ESA) ExoMars mission. Unchanged items include the ongoing Discovery missions, New Frontiers, and the overall Mars program, and specific research program items such as Lunar Science.

Dr. Green reviewed the R&A program briefly, highlighting the increase from $141M in 2007 to the proposed FY09 $219M budget. The restructuring of R&A resulted from an internal analysis of the program in terms of grant proposals (an average of $125K per proposal), and statistics relating to selection rate, with the target of a 33% selection rate. In particular, the Astrobiology program has been revived with a planned FY08 level of $41.3M and $49.5M in the FY09 projected budget. The community has responded well to this change, with 40 notices of intent having accumulated thus far for the next competition for membership in the Astrobiology Institute.

Lunar program

The Lunar Reconnaissance Orbiter (LRO) is scheduled to be launched in late October 2008, and will be transitioned into the PSD after its first year in orbit, where it will be funded from a science perspective. The division is supporting a Participating Scientist program ($80K per year per PI average, up to 4-year awards). Dr. Solomon suggested that an e-mail message be sent to alert the community as to the selections. Dr. Green took this action.

Ground-based observations are being coordinated in preparation for Lunar Crater Observation and Sensing Satellite (LCROSS), a lunar impactor that will determine ejecta composition. GRAIL, a new Discovery mission, will examine the lunar composition from "crust to core" using gravity measurements, Ka-band communications, and a 50- km-altitude orbit, during 3-4 months of operations. A new mission, Lunar Atmosphere and Dust Environment Explorer (LADEE) mission, will examine the atmosphere on the nearly airless body and levitation of dust on the lunar terminator. LADEE will be launched as a secondary payload on GRAIL in 2010. LADEE was not competed and is considered a strategic mission. The Science Definition Team (SDT) is headed by Laurie Leshin at NASA GSFC. Some instruments will be provided by the community. The SDT report is due in April 2008.

International lunar missions

International Lunar Network (ILN) missions will include a network lander mission. NASA is partnering with the international community on this program. The intent is to launch landers to the lunar poles in 2013-14. The envisioned core set of instruments will make seismic and heat flow measurements using 6 or 8 nodes on the lunar surface, on both the front and back sides of the Moon, with a communications relay. Next steps include an informational briefing during Lunar Planetary and Science Conference (LPSC) week on March 11, a multi-agency meeting at the Lunar Planetary Institute (LPI), and a core instrument agreement in December 2008. In response to a question, Dr. Green expected the lifetime of the mission to be multiple years. Radioisotope Thermoelectric Generators (RTGs) deemed necessary for such a lengthy mission are under discussion, but at present there are no solid plans for nuclear power. Site selection will be decided by science groups, including SDTs at NASA, across multiple agencies. International space agencies that might be interested in this mission, besides France's CNES, include Canada, ESA, Japan's JAXA, Great Britain, Russia, and Germany's DLR.

Other lunar activities

The Moon Mineralogy Mapper has been delivered to India, and a June launch is anticipated for Chandrayaan-1. The Lunar Advanced Science & Exploration Research (LASER) Program has received about 160 proposals, many for up to 4 years, and will be supported jointly with ESMD. ESMD also has a variety of analog campaigns such as Moon and Mars Analog Mission Activities (MMAMA), a small pilot program. Technology and Instrumentation, Lunar Science and Sortie Opportunities (LSSO), the Planetary Instrument Definition and Development Program, and Discovery mission and Scout activities are also included in these activities. NASA has created the Lunar Science Institute (LSI), modeled after the NASA Astrobiology Institute. LSI is envisioned as an exploration and science institute, with anticipation of some funding from the Exploration Systems Mission Directorate (ESMD) to some distributed nodes, with the central node to be located at Ames Research Center. A search is under way for a permanent director. David Morrison has been appointed Interim Director. The first Lunar Science Conference is slated for July 2008 at the NASA-Ames conference center. A Lunar Science Roadmap workshop is due to be held in August 2008. Committee members requested more detailed information about Roadmap planning.

Outer planet flagship mission

In the Flagship missions, studies for Europa, Titan, and Jupiter systems have been selected, with down-selection due shortly.

Missions of Opportunity

Upcoming opportunities include a Stand-Alone Mission of Opportunity Notice (SALMON). The principal investigator (PI)-qualification matrix for large missions has been relaxed in response to community concerns. Currently, a minimum of 4 years experience in a lead role on an orbital or deep space mission, or two, 2-year experiences in a lead role in same, will be required of PIs. The SALMON Announcement of Opportunity (AO) schedule is as follows: NASA is releasing a draft for comment this week and will accept comments for 60 days, with a release due in May 2008, proposals due in August 2008, and selections to be announced prior to February 2009. SALMON is expected to be an annual opportunity.

Types of Missions of Opportunity will include traditional, U.S. Participating Investigator, New Science missions using existing spacecraft, small complete missions, and focused opportunities. There has been no change in ITAR rules; however working as a member of a science team should not be problematic in this regard. Cost caps differ: complete missions will run on the order of $1M for microsatellites to tens of millions for new science missions using existing spacecraft. There will be separate slots for SALMONs for each division. The key is whether each division decides it has enough money for each MoO.

New Frontiers

New Frontiers is the next major AO after SALMON. The hard money starts in 2010 and the cost cap will be slightly higher than previous caps. NASA has yet to decide whether to include the cost of the launcher.

Plutonium reserves

Current assumptions are that the NASA plutonium supplies and RTGs will be quite limited (10 kg total-$17M per year purchasing power). Processing will be done in the traditional way at Los Alamos National Laboratory under the Department of Energy aegis. The timeframe for availability of RTGs is 2016/2017.

Division response to PSS findings

Dr. Green reviewed the division's response to PSS findings and recommendations, stating that PSD has restored R&A, has taken steps to maintain the Arecibo Observatory, jointly with the National Science Foundation (although some issues are open in terms of the specific language of the 2008 Appropriations Act), has created a Small Bodies Assessment Group, and has addressed committee findings on the Lunar Precursor Robotic Program.

Mars Program

Doug McCuistion, Director of the Mars Program, reviewed the Mars portion of PSD activities. He reported that the overall health of the program is good. The Mars Reconnaissance Orbiter (MRO) has experienced some problems in operations, but is generally rated Green. Rovers have been rated Yellow due to the effect of Mars winter (low solar energy). Mars Scout has been slipped due to conflict of interest. A selection is expected, however, by the end of summer 2008. A 2013 launch is now anticipated. In ESA's ExoMars program, NASA has sent letters to PIs requesting statements of work and milestone flow descriptions by the end of this calendar year. ExoMars is running short on funds. ESA delivery date negotiations have been completed for UREY (a biomarker fingerprint instrument) and MOMA, a mass spectrometer. A Mars Program Architecture is due to the Office of Management and Budget (OMB).

Phoenix is scheduled to land on Mars on May 25, 2008, and is looking good. A NASA Program Management Council (PMC) will be held in May. MSL has a significant funding problem, but there are no technological showstoppers. There will be major international MSR meetings in March, June, and November of this year, the latter being an ESA ministerial meeting). Other activities include FY10 budget preparation.

Mr. McCuistion reviewed details of the FY09 President's budget pertaining to Mars. In response to a question, he conceded that the Scout slippage is increasing the cost cap, based on both economic inflation and launch vehicle costs. The Mars 2016 profile starts in 2010 and will need to be ramped up appropriately. The Mars Technology program stands at a flat $410M per year, and could be a source for funding MSL overruns. Instrument funding, however, has been retained in the Technology program. Mars 2016 missions had previously been on the scale of Flagship missions: an Astrobiology Field Laboratory had been a leading candidate, based on MSL architecture, with mid-rovers on the Mars Exploration Rover (MER) scale, and a NetLanders mission with international cooperation. At present, however, there is about $800M available for a small mission, probably an orbiter or small lander, and perhaps a rover following shortly thereafter. For the benefit of new members, Mr. McCuistion reviewed Mar Exploration Program budget reductions from an historical perspective, recounting OMB decisions dating back to 2005 and 2006 that have subsequently forced NASA to perform considerable Mars re-planning activities.

The Mars Data Analysis Program (MDAP) has been improving, and the Mars Fundamental Research Program (MFRP) has a nearly 40% selection rate, with a healthy spread across disciplines. MSL had a critical design review (CDR) in June; current estimates exceed MEP's ability to fully fund a 2009 launch. Reasons for this shortfall include a $30M payment for the Phoenix overguide. In response, $62M in "capacity" was created for MSL. Thermal protection system problems surfaced after de-scoping actions. The heat shield will serve as a testbed for the Crew Exploration Vehicle (CEV). It is now estimated that an additional $130 to 4160M will be required to complete MSL. Most of this money is FY08, and the program is looking for ways to bridge the gap; the choice is to seek funding from outside the program or slip the launch. A meeting will be held in late March to consider whether MSL is technically feasible in 2010 or 2011, as well as financial options for 2009; this will not be a decisional meeting. The issue is being tracked on a weekly basis, and a final decision is slated for mid-May. The majority of deliverables should have been received by then; there no major technical issues. An additional $300-400M will be required for a 2010/11 launch, and an extra year in cruise will be required. In response to a question, Mr, McCuistion provided some background on how some key instruments, such as ChemCam, were re-manifested for MSL, with the help of Los Alamos National Laboratory. There was brief discussion on holding a Lessons Learned activity to pinpoint the origins of MSL's cost overruns and to emphasize the importance of technology development.

MEP – Next decade

Mr. McCuistion reported planning activities for the next decade on Mars. A competed Scout aeronomy mission is planned for 2013, the first element of MSR in 2018, and the second element in 2020. The mission order depends on budget, international cooperation, and the nature of the 2016 mission. A 2016 orbiter may be possible, depending on the outcome of the budget analysis. NASA has been planning the next decade with community support. The Goals Committee is revising its document, which will be released at the LPSC. A Mars Architecture Assessment Team is in place to evaluate Mars architecture. An MSR Science Analysis Group (SAG) has a final report due in mid-December 2008. The Next-Decade SAG is covering next decade science with an emphasis on sample return, with an interim report planned as input to the International Mars Architecture for Return of Samples (iMARS).

Mars Sample Return

There has been good progress on international collaboration on Mars Sample Return. The objective overall is to develop an affordable and successful sample return mission. The cost of a joint mission is anticipated at $4-5B, with U.S contributions capped at $3.5B. Significant efforts are under way to plan internationally-dependent Mars sample return missions. New planning for MSR began in Fall of 2007. MSR's expanding international tenor includes plans for an ESA orbiter in 2016, to demonstrate capturing and caching a sample. Recent progress includes JPL Mars Program Office (MPO) team engagement. An MSR Technology workshop was held in February 2008 and NASA architectures are moving along and are aligned pretty well with ESA.

Mr. McCuistion reviewed a summary of MSR Technology Workshop recommendations, which include backward and forward planetary protection, pinpoint-to-precision landing (100 m to 3 km), Earth entry vehicle and Mars ascent vehicle parameters, rendezvous, and sample capture. The Defense Advanced

Research Projects Agency/Air Force mission, Orbital Express, provided some good data for autonomous docking maneuvers. ND-SAG has determined that a suite of 5-8 samples and significant surface mobility of the rover will be necessary to select sufficient diversity of samples, and at least 6-12 months on the surface. There has been a fair amount of dissent in weighing mission needs against cost. Other recommendations are that samples must not be commingled, that encapsulation must be air-tight for at least some samples, and that a small number of carefully managed samples are more valuable than a larger number of poorly managed samples.

A draft baseline architecture for Mars Sample Return includes an orbiter, and a lander with rover and appropriate instrumentation. One landing site with one lander is also recommended, while precision landing is considered a requirement. Separate packaging and thermal control of -20ºC is also desirable. A putative mission timeline would have the first leg launching in 2018, and the second in 2020. The sample would be treated as a biohazard, to be returned to Earth directly (i.e., no dwelling time on the International Space Station). More realistic cost estimates are expected soon. NASA has presented some draft number before the Europeans and Alan Stern. The costs are being refined in the PPBE (Planning, Programming, Budgeting and Execution) process. Reasonable estimates may be available by June 2008. Mr. McCuistion considered $5B a reasonable estimate, with international input of $1-2B, not including reserves of 30-50%. In response to a question, Mr. McCuistion described the international community as being enthusiastically interested in sample return, from instruments to orbiters. Every interested party would like a curation facility. The Mars Sample Institute is potentially conceived as an international center, but the receiving facility has been thus far construed as U.S.-only.

Discussion with Associate Administrator

Associate Administrator for the Science Mission Directorate, Alan Stern, opened the discussion with PSS by noting highlights of the SMD Flight Program. Over the last year, SMD has revamped the launch schedule with an intent to repopulate the launch calendar and rebalance the missions amongst divisions, scaled by development costs. In a steady state, SMD aims to launch roughly $2B per year in missions. New starts are plentiful. The lunar program is healthy and relatively vibrant, with 7 spacecraft scheduled to launch to the Moon by 2014. Dr. Stern reviewed the Mars budget history and averred that despite ups and downs, the Mars budget has run at an average of 27.3% of the SMD budget from 1985 to 2013. Some of the budget has been shifted to Earth Science over a 5-year period. However, the Mars program is still the largest program in PSD.

In terms of Entry, Descent, and Landing (EDL) capability, MSR will be designed along the Sky Crane concept. Studies are underway on precision landing vs. a limited amount of controlled descent and entry. In response to a comment on realistic cost estimates, Dr. Stern explained that the current philosophy is to develop only one technology per mission. In addition, it has been recognized that past Decadal Surveys have underestimated mission costs. As a result, NASA is also trying to address Decadal Survey development, which would ideally include independent cost estimates as a requirement; production of a baseline plan on a baseline budget; and tripwire costs (the cost at which the mission would be considered too expensive for the science to be returned). There was general agreement that technology development was integral to cost control, and the committee was pleased to see this philosophy at work in lunar technology development.

Discussion

The floor was opened for a general discussion. Dr. Stern addressed the paucity of launch vehicles and the development of next-generation launch vehicles. Delta II vehicles are nearly nonexistent: NASA will fly the remainder through 2011. There are small launch vehicles available, or very large vehicles such as the Atlas V or Delta IV, with a medium launch vehicle lacking. NASA has tasked a Working Group chaired by Dr. Stern and William Gerstenmaier to further examine the solutions. Taurus and Falcon vehicles have yet to be proven. NASA intends to release a request for information (RFI) to all launch vehicle providers in April 2008 with the intent to buy rockets for launches out to 2015. The latest prediction is that EELVs are going to double in cost. Ares I and Ares V are vehicles over which NASA will have some control later in the next decade, but the costs are uncertain.

In response to a question concerning nuclear power supplies, Dr. Stern explained that there is enough plutonium for MSL, an OP flagship, and a Stirling engine for a Discovery mission. Lunar nodes can be kept alive on a limited RTG supply by switching to survival mode at night. In response to committee concerns about the restructuring of the Mars program and an inadequate budget for Mars Sample Return, Dr. Stern cited his responsibility to SMD as a whole and not the Mars program *per se*, and stated that in spite of such concerns, the National Research Council has graded the Mars program very highly. However, other mission areas were not graded as highly, such as the OP flagship mission. Community feedback for the FY10 budget could conceivably help the Mars program. To that end, there needs to be consensus amongst all the planetary communities on the Mars issues before NASA can specifically respond to the concern. NASA is aware of the problematic implications of the outyear budget for MSR and is looking at ways to address it. But something has to give, and the issue remains cost control. It will take a while for recent efforts to percolate through the system.

Committee members asked Dr. Stern to re-address the PI qualification matrix, and whether any studies were able to correlate lack of PI experience and mission failure. Dr. Stern responded that there were no such results and added that the nature of mission failure is multifaceted, and NASA is trying to block all those potential pathways to failure. He commented that it was a bad idea to go to OMB with an inexperienced PI and plead for new starts. In response to concerns about the International Traffic in Arms Regulations (ITAR), Dr. Stern cited NASA's proactive efforts in smoothing the way for international cooperation, having made its first trip to JAXA. NASA has also met with ESA twice this year and three times with CNES. The situation "won't turn on a dime," but is expected to work out. Typically international collaborations involve hardware; NASA is now considering a shared mission queue, with international teams alternating missions. Sharing science teams can help to avoid ITAR issues and potentially yield two OP flagship missions — one led by NASA with international participation and one led by an international partner with NASA participation. The concept is already working well with the Galileo and Cassini-Huygens missions.

In response to a call for a joint Decadal Survey-European vision effort, Dr. Stern felt that such an effort should be initiated by a grass roots contingent. ExoMars can be seen as the ITAR testbed for large-scale hardware sharing, which may answer some lingering questions about international sample-sharing. In terms of SMD and ESMD sharing a long-term vision for space, there is much interchange and personal chemistry between the two divisions. SMD has picked up lunar robotic science, and the two divisions are

jointly funding studies and activities. There is much more integration. In response to a question about LSI guidelines, Dr. Stern described its vision as being rooted in building a lunar science community, setting up centers of excellence with different objectives, and performing fewer transactions as an efficiency measure. Dr. Green suggested the NRC report, and activities in the LAT I and II community, as sources of information. Committee members recommended placing *in situ* resource utilization (ISRU) within the Lunar Architecture's critical path to address sustainability for Moon and Mars exploration. Lastly, in response to a question on contacting representatives in the context of the budget issue, Dr. Stern advised that letters are better than e-mail, but that the biggest thing the planetary community can do is to achieve consensus. Scientists freelancing for their favorite planet do not play well on the Hill.

Ethics Briefing

Ms. Rebecca Gilchrist presented the mandatory annual ethics briefing for the Committee.

Requirements for a Mars Sample Return Receiving Facility

Ron Atlas, Chair of NASA's Planetary Protection Subcommittee, covered aspects of planetary protection in preventing both forward and backward contamination of Mars during a sample return mission. Concerns include preserving investment in space exploration and future habitability of both planets. To prevent contamination of Earth, NASA begins with a presumption of ignorance. The Outer Space Treaty outlines some of these tenets, as do NASA's planetary protection policy and specific requirements embodied in NASA Policy Documents (NPDs). The Committee on Space Research (COSPAR) also sets guidelines, among them the statement that any sample return from Mars will require the highest level of containment (Level V). Level V requirements for Mars state that the spacecraft itself must be "clean," and that returned samples must undergo containment and/or sterilization techniques in order to achieve true freedom from biohazards before release to the scientific community. The 2002 Lederberg draft protocol needs to be continually updated in order to refine requirements for life detection and biohazard assays at any planned receiving facility. It will take 10 years or more to develop a receiving facility, and along the way, any preparations must tie facility milestones to mission events and follow the National Environmental Policy Act (NEPA) regulations for biosafety. In addition, Biosafety Level 4 conditions will also be required, and thus may be delayed due to the political climate. A receiving facility will have extraordinarily complex airflow system (both positive and negative airflow). In response to a question as to what conditions needed to be met before the sample could be released for curation, a lively discussion ensued as to the proper handling of the sample and the potential for sterilization procedures to destroy the very evidence being sought. Catharine Conley, Executive Secretary of the Planetary Protection Subcommittee (PPS), asserted that instructions to preserve such evidence already exist in current NASA protocols. Public concerns about containment facilities were also noted.

The latest PPS recommendations to the NASA Advisory Council (NAC) include a call for NASA to actively engage in advanced planning processes to contain returned samples, and to continually update documents and processes to avoid delay and preclusion of important science questions. PPS concluded that NASA should act now to comply with mandatory planetary protection enforcement. In response to a question on how forward contamination is being dealt with in the design for MSL's sample cache, Dr. Atlas explained that MSL must model the distribution of particulate matter and perform a microbial

and molecular inventory of craft and assembly facility. For MSR, Viking-level cleanliness would be required. Cost continues to be an issue, despite the fact that a full-system microbial reduction can save an entire mission. In order to move forward on this issue with an integrated voice, PPS and PSS chairs, in addition to representatives from CAPTEM, should present the NAC with the same message, while maintaining representation on relevant committees. ESA and NASA will be working on meetings for refining planetary protection and are inviting members of the planetary community to determine the science that needs to be done. The Mars Exploration Program Assessment Group (MEPAG) needs to weigh in on this matter, as well. Dr. Atlas agreed with committee recommendations that initial characterization of samples must be carefully documented, and that curation must be performed in the sample receiving facility, i.e. that the science and handling must be done in lockstep.

Analysis Group and MOWG reports

VExAG

Ellen Stofan, the chair of the Venus Exploration Assessment Group, presented the latest findings. The Venus Flagship Study Science and Technology Science Definition Team (STDT) was formed in January 2008, and is due to present an interim report to Dr. Green by May 2008, with a final report due in Fall 2008. The group has held a preliminary discussion of some seismic instruments for the mission. The next VExAG meeting will take place May 7-8, 2008, in Greenbelt, MD. The Venus-Earth Connections Initiative (an atmospheric studies discussion, largely) will be briefed to NASA Headquarters in May as well. Dr. Stofan reported a new enthusiasm for Venus science in light of these recent accomplishments.

LEAG

Clive Neal presented the report of the Lunar Exploration Assessment Group (LEAG). The LEAG meeting of October 2008 is scheduled to coincide with the LRO launch at Cape Canaveral (scheduled for October 31st), and will be focused on questions pertinent to achieving the President's Exploration Vision. There will be plenary and concurrent sessions, held jointly with the International Lunar Exploration Working Group (ILEWG) and Systems Requirements Review (SRR). LEAG has been charged by the NAC to develop a Lunar Goals Roadmap, a draft of which has been subtitled *Exploring the Moon in the 21st Century- Why Are We Going to the Moon*? Initial answers include the pursuit of scientific activities to address fundamental questions, prepare for Mars exploration, and to extend human presence to the Moon, preceding the construction of a permanent base.

Theme 1 of the Roadmap describes the use of the Moon as a "witness plate" (a tape recording of the history of the Solar System) for Solar System evolution. Additional objectives are to understand the formation and current state of the Moon, to use the Moon as a platform for Astrophysics, Heliophysics, and Earth Observation studies, and to regard the unique lunar environment as a research tool. Theme 2 involves the use of the Moon to prepare for Mars, using it as a technology testbed for systems, flight operations, etc. Theme 3 addresses the concept of extended human presence on the Moon, and the creation of an initial infrastructure looking toward a sustainable base on the Moon. Themes and Goals will be posted on the Web this week for public comment, for a period of two weeks. A special Roadmap session at the Lunar Science Conference will be held at Ames Research Center in July 2008, and the

Roadmap itself will be unveiled at the October LEAG meeting. Dr. Neal added that NASA still needs an exit strategy from the Moon that would allow subsequent travel to Mars: commercial on-ramps, centered around ISRU, will be vital to this effort. NAC has also requested that LEAG review the Lunar Architecture Team-2 (LAT-2).

In conclusion, Dr. Neal reported that the LEAG views the 2009 budget with optimism. Committee members reiterated concern about the proper rendition of ISRU in the Roadmap, and Dr. Neal agreed that the issue would be a priority in the development of the Roadmap.

MEPAG

Jack Mustard presented the activities of the Mars Exploration Program Assessment Group, first observing that NASA's MEP has been very successful with its "Follow the Water" strategy. MSL marks the transition to understanding Mars' habitability, and there is strong public and bipartisan support for this program. The science and engineering communities are poised to embark on the MSR mission, in the context of a balanced program. Since last June, there has been tremendous activity in the MEPAG with the initiation of a MSL Cache SAG, Next Decade SAG (ND-SAG), Human Exploration of Mars SAG (HEMSAG), and a Mars Architecture Tiger Team. The February MEPAG meeting was attended by 100 people, indicating great interest in the community. Dr. Mustard expressed concern, however, that the 2009 and outyear budgets are insufficient to meet the goals of the program as currently stated.

Dr. Mustard illustrated the dip in funding from 2009 through 2013 that is jeopardizing the integrated nature of the Mars program. MEPAG has assessed the Mars architecture, which is science-driven based on the recommendations of the Decadal Survey and other community input, and has examined budget-driven architectures in both increasing and flat budget scenarios. MEPAG's key conclusions are that SMD can maintain the Mars program with an adequate budget; within the current budget plan, however, it appears that only one Scout mission can be accomplished between MSL and MSR, resulting in a potential 11-year period between Mars landings, with a four-year gap between flight elements of MSR, and only 5 months of surface operations for an MSR rover launched in 2022. The implications are that any MSR will require a substantial international contribution. The community is deeply disappointed with the current scenario. In all Mars planning exercises, major technology development is required at least 5 years prior to the MSR development; and existing assets could support future Mars missions.

MEPAG endorses the sound SMD MEP architecture, but is concerned that all MSR options will require international participation and significantly increased funding in outyears. The Mars program needs a commitment of $200-300M in the near-term budget to show a commitment to MSR. PSS should carry forward this message to make the budgets credible and ask that the Mars Exploration Program monies be restored. The committee had a protracted discussion with the conclusion that the Mars Exploration Program budget could not sustain SMD's documented MEP architecture under current budget projections. Several issues arose, including a consideration of eliminating MSL, the scientific necessity of obtaining MSL results before launching MSR, greatly reduced viability of the Mars program at $300M/year, a request for increased funding in the FY10 budget, and a simple statement from PSS to NASA that the program as currently funded is not tenable.

OPAG

Fran Bagenal reported on the activities of the Outer Planets Assessment Group. Acting on OPAG's suggestions, NASA has funded four Flagship mission studies: Europa, Titan, Enceladus, and the Jovian System Observer, and has obtained realistic cost estimates for these. The Europa mission concept includes radar observations, spectroscopy of the surface, and ocean-surface coupling, amounting to a very complex and difficult mission. With the arrival of the new Associate Administrator, OPAG recognized it would have to accomplish such a mission on half the amount originally posited. The Jovian System mission concept is not as compelling as that for Europa. The Enceladus mission, centered around the active icy moon of Saturn, would attempt to characterize the plumes that have been observed during the Cassini mission. The biggest disappointment with this mission study is the instability of its proposed orbit, rendering it technically infeasible. The Titan mission would require aerocapture, and would be expensive and complex due to many mission elements. ESA has proposed LAPLACE, a mission to Europa and the Jovian System. Another mission concept is to look at the Jovian system as a whole, then use a Europa orbiter; or a Titan mission that involves some study of Enceladus; or a Titan Explorer. Each mission would require $2B. NASA is now funding follow-on studies for the Europa, Titan, and Jovian System mission concepts. Reports are to be delivered this summer.

OPAG has also been wrestling with the issue of Pu-238 availability, as outer planet missions will require a constant supply and regular production of RTGs. OPAG requests that NASA and DOE clarify their plans for Pu production, and get Stirling RPS testing accomplished on a Discovery mission. OPAG also suggests the consideration of Uranus and Neptune and how they compare to Jupiter and Saturn in composition (Hydrogen vs. water CH3, NH3) as possible goals of future outer Solar System missions.

At the next PSS meeting, OPAG plans to report on the progress of Flagship mission studies, technology development for Outer Planets, strategic planning for the next outer solar system flagship mission, a Cassini extended mission, and an update on the Science Plan. Other topics under consideration are aerocapture at Titan, and development of instruments for surviving hostile environments. Technical feasibility will be a key issue for choosing the next mission, and planetary protection is continually under consideration, especially at Europa.

SBAG (Small Bodies Assessment Group)

Faith Vilas, Chair of the newly formed Small Bodies Assessment Group (SBAG), briefly presented the initial activities of the group, which was organized in October 2007. SBAG is planning its first meeting at the Applied Physics Laboratory (APL) in July 2008, in conjunction with the Asteroids, Comets and Meteors (ACM) meeting. Two meetings per year are planned, and the group has already given input to SMD re: IPEWG. SBAG's charter is to keep small bodies in focus, while reflecting on such questions as: How big can a small body be? Dr. Vilas anticipated that SBAG will overlap with different AGs, including satellites of other planets.

CAPTEM

Chip Shearer, Chair of the Curation and Analysis Team for Extraterrestrial Materials (CAPTEM) presented and reviewed CAPTEM functions, which are inherently a bit different from those of other

Assessment Groups. CAPTEM, which has its roots in the Apollo missions, oversees sample return and allocation of planetary materials. CAPTEM also provides guidance and analysis for NASA sample curation and sample science expertise, and sponsors sample science initiatives and workshops. The group is comprised of several subcommittees, an ISRU Advisory Group, and a Mars Sample Return Roundtable, which will be the organizing committee for the MSR workshop in April. Dr. Shearer reviewed some recent requests for lunar samples, and material from the Stardust (Wild 2 comet), Genesis, and cosmic dust missions. Lunar-focused activities for CAPTEM are at present centered on the handling and allocation approaches for so-called "new Apollo" samples (sealed freezer samples from the Apollo missions that have not yet been breached). CAPTEM is also in the process of reviewing a putative air-handling system for a future lunar sample facility.

NRC's Moon II report, which examines the science context for exploration of the Moon, has recommended a focus on the potential need for curation for new samples, and has asked that CAPTEM assist in reviewing the capacity of current facilities. In addition, CAPTEM's Stardust Subcommittee is preparing a preliminary review for nondestructive evaluation of the first test sample from the Stardust mission. A 2008 workshop on Stardust science is in the planning stages. Dr. Shearer also described the Stardust@home project, a citizen science project that encourages volunteers to search images for tiny interstellar dust impacts. Participants must pass a test to qualify to register to participate. After registering and passing the test, participants have access to the web-based "virtual microscope" that allows them to search each field for interstellar dust impacts.

Dr. Shearer outlined several sessions that will be held during an MSR workshop (Ground Truth From Mars, April 2008), a workshop for analyzing, buying down the risk, and increasing the competitiveness of sample return missions. Report and findings will be posted on the CAPTEM website following the Spring CAPTEM meeting.

Planetary System Science Management and Operations Working Group (MOWG)

William Bottke (SwRI), participating by telephone, described the Planetary System Science Management and Operations Working Group (PSSS-MOWG) as a sounding board for NASA Program Managers (PMs) and other Headquarters staff. Its primary focus is R&A and ground-based facilities. Because the MOWG is not an advisory panel, its findings can be presented and acted upon more quickly, and community memory can be maintained on a 3-5 year timescale. This is a good resource for PMs and PIs. The MOWG also provides feedback on R&A program balance and acts as a safety valve on the process through candid communication. PSS-MOWG duties include the discussion of the program balance in the PSS cluster, ground-based facilities, funding status, maintenance issues, and community access to large-aperture ground-based facilities (e.g., Keck Observatory). The group also deals with near-Earth Objects (NEOs), the future status of the Minor Planet Center, reports on the discovery status of potentially hazardous NEOs, and produces white papers on various facilities. Upcoming issues for PSS-MOWG are suborbital issues such as the value to planetary science of sounding rocket and balloon missions, access to Keck and other facilities, and ongoing changes to R&A. Dr. Bottke announced he was seeking to attract two or three new members to the MOWG. Some committee members took the topic of facility access off-line, amid suggestions of trade time to ameliorate the high cost of large-aperture telescope access.

Discussion

Dr. Solomon queried committee members for further topics of discussion. Concern over budgetary barriers to carrying out Mars Sample Return was the most visible topic. Arguments both for and against advocating sample return touched on the perception that Mars had "had its day in the Sun" and whether undue emphasis on the Mars program violated the spirit of its integration into the Solar System. Some felt that the holistic view precluded the ability to quickly respond to new discoveries. Other arguments for Mars sample return emphasized its potential for revealing prebiotic chemistry and aspects of Solar System history, for providing successful science results to feed forward into other planetary exploration, and to procure scientific results within the space of a human lifetime. In sum, however, the committee recognized that SMD's balanced program, which is preferred by the community, exceeds total funding and has improper cost phasing.

Tuesday, March 4, 2008

Dr. Sean Solomon convened the meeting.

Update on Lunar Architecture

Dr. Geoff Yoder, ESMD, presented an update on lunar architecture activities, focusing on the 2005 Authorization Act and the six themes of human civilization, global partnerships, scientific knowledge, economic expansion, exploration preparation and public engagement. Guidelines for the architecture are programmatic, emphasizing participant and exploration flexibility. In the Dec 2006 meeting, key findings were to build an outpost at a polar site (this has since changed), preserve options for other outpost sites, and maintain an open architecture to encourage dialogue and collaboration. In response to a question about mobility from Shackleton crater, Dr. Yoder explained that mobility is considered key within the architecture, but is not exclusively a NASA task. NASA has committed to certain items such as the launch vehicle, CEV, lunar lander (including ascent, descent and basic habitation), and initial extravehicular activity (EVA) system for CEV and initial surface suit, and basic navigation/communication functions. Open for international and commercial cooperation are items such as development of a long-term surface suit, long-duration habitation, etc.

Dr. Yoder reported on the results of the Preparing for Lunar Capabilities Concept Review, held in June 2008. The review focused primarily on the transportation system (Ares vehicles, transport of large upmass). The surface system concepts are expected to be finalized within at least a year, perhaps two. Cxt_Lunar is carrying out analyses in 5 different modules: surface system design/analysis, strategic analysis, requirements and integration, mission operations, and integrated transportation performance. These latter topic areas are overseen by the Outpost Science and Exploration WG (OSEWG) and ESMD. Second phase activities will build on LAT-1 decisions: enable sustained lunar presence early, ensure that the architecture supports the six themes, support Mars analog establishment, allow earliest partnership for commercial and international, and maintain public engagement.

Dr. Yoder described the hybrid approach in use for addressing the transportation system in tandem with the surface system, employing a mobility-with-leg/wheel concept, early delivery of small agile pressurized rovers, and a cargo lander for transporting major components to the surface. An extended

surface exploration approach supposes a capability for a mobile habitat, a scenario in which the crew drives separately in a pressurized rover to extended sortie sites (potentially hundreds of kilometers). Options that have been identified in LAT-2 include nuclear power for surface operations, all elements delivered with crewed flights, and lander with integrated mobility capability. Dr. Yoder described six different options, among which were a complex "Station on the Moon" design, a single monolithic module with extensive sortie capability, and designs which combined elements of both, with varying implications for commercial and scientific opportunities. A design for a small, pressurized rover was notable for its ability to partially integrate suits to allow ingress or egress in 10 minutes, with minimal gas loss (modern suits require 3 hours of preparation, with pre-breathing). The rover would be built with a dome roof for visibility, an exercise ergometer, and pivoting wheels to enable crab-style driving for docking. The suit-port for ingress/egress would utilize two hatches, never depressurizing the module.

The sixth option supposes the use of nuclear fission as a power source, with a 45-kW capability (U-235). Advantages of a nuclear system are that it is not dependent on sunlight, provides power for ISRU, and supports Mars concepts. However it is not a flexible option; the reactor anchors the exploration site, and the scheme is not failure-tolerant. Some solar power would be needed initially, and emplacement is challenging (reactor must be buried, perhaps requiring explosive excavation) and carries political sensitivities. Some DOE involvement is assumed in development.

Option discriminators are affordability, cost, safety, risk, and sustainability (e.g., cumulative crew-stay days). Crew surface time *per se* does not favor one option over any other.

The NRC document, *Scientific Context for Exploration of the Moon*, calls for enabling activities critical in near-term and advocates ties with international programs, exploration of the South Pole-Aitken Basin (viewed as challenging), and diversity of lunar samples. Six themes are broken into 45 SMD science objectives, which have since been prioritized and grouped into sample science payloads such as a lunar telescope and an environmental monitoring station.

Dr. Yoder felt that the lunar architecture thus far has remained consistent with NRC's prescribed priorities, by utilizing robust Ares I and V concepts, maintaining an open architecture, focusing on early exploration, facilitating super-sortie mode, and planning for the development of an early small, pressurized, nimble rover. Early topographic data (150-m to 20-m resolution) have shown that the Shackelton crater poses an extremely challenging environment for landing, which will drive the precision of the landing ellipse. LRO data will also be needed to refine decisions for a landing site. The favored option overall is to use smaller modules for habitats, pressurized rovers for range, and solar power. Cost estimates for a hybrid option (solar/nuclear) have not yet been completed.

Update on Outpost Science and Exploration Working Group (OSEWG)

Kelly Snook, OSEWG co-chair, presented recent activities of the OSEWG, a group that was chartered jointly by SMD and ESMD in 2007 to guide outpost-related science and exploration planning. OSEWG is also co-chaired by Marguerite Broadwell (ESMD) and Gordon Johnston (SMD). The group has representation from Constellation (CxAT) and is considering having a representative from the Lunar Program Offices. SOMD is represented as well. OSEWG is comprised of three subgroups−lunar data

integration, surface scenario, and analog missions. The working group feeds into Constellation and technology development areas that impact science requirements for the lunar architecture. OSEWG is tasked to develop science reference scenarios; prioritize time-phasing to maximize scientific return; provide input to research calls; flesh out unknowns related to science operations; identify new technology needs; and conduct systematic reviews of exploration requirements documents from a science perspective. In response to a question, Dr. Snook explained that the OSEWG intends to engage the community through workshops and commissioned studies.

The Surface Scenario group is studying variables affecting surface scenarios:

- Mission duration
- Landing site
- Mobility
- Landed science payloads
- Return mass capabilities
- Sortie vs. outpost
- Navigation and communications

The group is also examining representative science payloads to help develop surface scenarios.

The Analog Missions group is studying how to reduce risk and is facilitating and coordinating SMD/ESMD/SOMD/ARMD analog activities, providing the analog community with needs requirements and outstanding problems needing investigation. Issues to be investigated include training, technology integration, and human health and performance. Among the science issues are traverse planning, sample return, laboratory analysis, documentation, and sample and data acquisition. The Surface Scenario and Analog Missions overlap and iterate in broad areas.

The draft objective of Lunar Data Integration subgroup assumes that lunar planning will use data that already exist and coordinate acquisition and transformation of data from past, present, and future mission so that Constellation can use it (e.g., LRO mapping data, SMD planetary data systems, lunar surface operations simulation activities). The US Geological Survey (USGS) Astrogeology Branch is also engaged in this process, as is the International Planetary Data Alliance. The Local Data Integration System (LDIS) will also map NASA needs onto tasks, identify and deal with gaps and overlaps, and monitor and contribute to International Lunar Data development.

OSEWG will create terms of reference for the three subgroups within the next weeks and implement plans for workshops and studies. In June and October, ESMD, SMD and SOMD are planning to conduct joint field tests to help to drive architecture in the right direction. On an ongoing basis, the group is engaged in SMD research calls, ESMD participation in workshops and conferences, and science reviews of ESMD and Constellation requirements, the latter of which addresses an original NAC recommendation. The committee urged OSEWG to stay engaged with the LEAG in order to address changing requirements and the emergence of community concerns over specific items, such as the recommendation that laboratories not be located in habitats. Dr. Snook replied that the OSEWG is studying the formal process for flagging the issues and getting them into the requirements, and she also cited the need for community consensus before actually altering requirements

Discussion

Dr. Solomon requested that the Assessment Group chairs summarize their most recent deliberations in writing to ease their communication to the NAC Science Committee. They were also asked to include any recommendations that the AGs desired to be carried forward to the NAC.

Jim Head made a brief presentation outlining his concerns about the Mars program. The proposed FY09 budget cuts the Mars budget by half. Accelerated sample return is simply not supported by the budget. The current budget supports a Scout-scale mission at every other opportunity. This schedule is not in the best interests of NASA, the public, or the scientific community. Dr. Head recommended that NASA should clarify what a realistic budget and schedule would be to enable MSR, and obtain an augmentation to do so, as well as perhaps an augmentation for an Outer Planet Flagship mission. It may not be the right time politically to take money out of SMD to give to Earth Science, as this discipline may receive more funding after the election. At minimum, PSS should obtain clarification on what it will truly take to achieve the full Mars program leading to sample return within the stated time period.

Jack Mustard presented further arguments for supporting the entire Mars program. A 2016 mission Mars Science Orbiter (MSO) for trace gas measurement could guide site selection for MSR and could also serve as a communications asset for EDL. Dr. Mustard offered proposed language for the PSS letter and committee members provided further edits. The committee recognized the time imperative for MSR and international buy-in for supporting the mission.

NRC Committee to Assess Solar System Exploration

Wes Huntress presented NRC's "report card" on NASA's progress in exploring the Solar System, as recommended by the Decadal Survey. Dr. Huntress distributed the report to most committee members. The report is the outcome of a Congressionally mandated study, codified in the NASA Authorization Act of 2005, and represents NASA's mid-term grade, five years after initiation of the Decadal Survey. The report also reviews the alignment of NASA programs. In the case of Planetary Science, the NRC Committee reviewed the Mars Architecture Study in the context of resources available to the Agency. The Committee divided itself into 5 different subgroups reflecting the divisions at NASA: Science; R&A/Planetary Astronomy/DA; Technology Development and Infrastructure; Mars Architecture; and Flight Missions. The effects of a lean budget atmosphere were also addressed. Dr. Huntress briefly explained the grading system (academic; A-F), which included trend arrows. He praised the NASA staff for their participation, particularly Jim Green.

Dr. Huntress reminded PSS that this assessment was concluded on July 1 and thus does not reflect recent changes in SMD. Overall, NASA's summary grade in Solar System "achievement" is a B, which is a good grade halfway into the Decadal Survey's timeframe. The NRC Committee considered the program highly productive, with exciting missions and fundamental discoveries. One stand-out was NASA's new start for a New Frontiers program. The Mars program received the only A, based on the extraordinary performance of its Flight Program. Negative marks were given for the lack of a Discovery selection in 2004 and the absence of a new Europa mission.

The reduced budget for R&A and Technology Development was considered alarming, as were cost overruns, launch vehicle paucity, worries over the integrity and future of the DSN, and neglected

technology work on MSR. Fundamental conclusions at that time were that the program was in jeopardy unless changes were made. The overall Science grade was a B, due to excellent results from current missions, but with concerns about future. Upon learning of changes, the NRC Committee received a briefing from Dr. Green and Mr. McCuistion in August, and therefore wrote an addendum to the report expressing optimism on MSR. Dr. Huntress offered a personal view, which was to ensure that a $5B sample from Mars was sufficiently different from one that humans can find at Antarctica for minimal cost.

Recommendations

Dr. Huntress summarized recommendations. In Science, the next Decadal Survey should address a Neptune-Triton mission. He conceded that the previous Survey was unrealistic about Flagship mission costs, a factor that will play a large role in developing the next one. Astrobiology and Technology Development funding should be restored to previous levels.

In Flight Missions, the NRC Committee recommended that NASA apply more funds in pre-phase A and phase A, in a competitive program, to avoid cost overruns. Over the next decade, Flagship missions for both inner and outer planets should be considered, with a mission concept specifically for Europa. In addition, NASA should increase the rate of selection for New Frontiers, select two missions for Discovery, and return to the practice of conducting Senior Reviews every two years.

In R&A/Planetary/DA, NASA should restore stable R&A funding; integrate astrobiology; increase the fellowship program for early researchers in planetary science; establish formal contacts with the Large Synoptic Survey Telescope; and include software to track moving objects for JWST.

In the Mars program, NRC recommends that NASA actively plan for MSR, including precursor missions that identify well-characterized samples of geologic and biologic interest, with adequate monies spent upfront to retire risk. NASA should begin consulting with communities to understand state-of-the-art sample analysis (biosignature detection, particularly) and address gaps where necessary. Furthermore, technology investment must be carried out to reduce risk in the development of a Mars sample receiving facility; a sample return vehicle consistent with Planetary Protection guidelines; autonomous on-orbit rendezvous and docking capability at Mars for sample transfer; and a Mars ascent vehicle that can return to Mars orbit with a cached sample. There are significant questions of hardware survival under Mars conditions, according to industry studies. NASA should also make decisions about the 2016 and 2018 opportunities as well as seek community review of the latest Mars architecture and its budget implications.

Under Enabling Technologies, technology funding was viewed as a serious deficit, which impacted many areas of the Decadal Survey, and moving forward to next decade. Ralph McNutt addressed the details of this assessment. The Committee recommended that NASA develop a strategic plan for technology development independent of the flight programs, and restore funding to the New Millennium program (citing success of the Dawn mission, which is reliant upon ion engines demonstrated during the DS-1 mission). Potentially enabling technologies such as aerocapture cannot be studied without an infusion of technology development funding.

NASA should conduct a study of trade-offs of costs vs. risks of developing a Ka-band communication system, and whether optical communications will be necessary for data transfer in the 2013-23 timeframe. NASA should assess technologies necessary to MSR and analogous technologies for the Moon, Venus, asteroids, and other targets. Dr. McNutt felt that propulsion will be a "nightmare" for the MSR mission. NASA should fund the Small Aperture Receive Array for DSN and replace 70-m antennae with arrays of smaller antennae. Sufficient money needs to be spent on a regular basis for this technology development, over an adequate time period. This also includes infrastructure and launch vehicles.

Norine Noonan made some closing comments, expressing the hope that this report would help Planetary Science through the next Decadal Survey process. She aired some principal concerns, chief among them the uncertain budget and reduced expectations, as well as the personal feeling that on the domestic discretionary side the future budget outlook would be unprecedented in its deficit. Scott Hubbard interjected, in response to a question on length of planning time for missions, that at least 8 years would be required to develop MSR technologies. Sample return planning on a flat budget is expected to consume three opportunities, so the program must begin investing today.

The second area of concern expressed was Flight mission development cost growth, even while applauding Dr. Stern for his cost austerity. Dr. Noonan felt that this cost growth would consume the remainder of the SMD budget. Flight mission costs have been underestimated and must be corrected. This is a problem that NASA should take very seriously. Increased infrastructure costs are also a major obstacle to fulfillment of the Decadal Survey.

In response to a PSS question on directing attention to the areas of concern, Dr. Noonan replied that NASA should look at science return and what is needed to enable future exploration, as well as support for the next generation of Solar System scientists. Aside from that, the community needs to guide the most mature missions of high-priority, with the best chance of success. Dr. Green supported a proposed action to get specific criteria out to potential proposers on how to carry out cost estimations.

Discussion inputs

- Set up a mechanism through CAPTEM to transmit a unified PPS and PSS recommendation to NAC on a sample return facility. This was taken as an action item for the next meeting.
- Fiscal responsibility is key to future mission success. NASA should provide a formal assessment on why MSL became so costly, document these results and make them available to the community.
- Formalize the process for recommendations to Lunar Architecture and address the participation of the community in the OSEWG, and how OSEWG feeds forward into the Lunar Architecture.
- Address the apparent disconnect between LEAG and LAT-2, to ensure that the science goals of the lunar program be better articulated. LEAG should provide a Lunar Roadmap in order to address this concern.

Conclusion

Dr. Solomon expressed his appreciation for the service of 8 PSS members whose terms are ending between now and June: Drs. Hynek, Meadows (absent), Snoke, Taylor, Head, Dickerson, Borg, and Anbar (absent). The next PSS meeting was tentatively scheduled for June 22-23, 2008 at NASA Goddard Space Flight Center. Dr. Solomon adjourned the meeting.

Appendix A

FINAL AGENDA

Planetary Science Subcommittee Meeting

3-4 March 2008

Abelson Building*

The Carnegie Institution of Washington

3 March (8:30 AM – 6:30 PM)

8:30	Welcome, Introduction of New Members, Appreciations of Departing Members & Other Administrativia	Sean Solomon, Michael New
8:45	Planetary Science Division Update	Jim Green,
	• Impacts of 2009 President's Budget	Doug McCuistion
	• Discovery 2006 Selection	
	• Mar Scout Selection Postponement	
	• Status of New Frontiers AO	
	• PI Requirements for New Frontiers and Discovery Programs	
	• MSR and OPF Update	
	• MSL Status Update	
	• LRO Status Update	
	• ExoMars Update	
10:45	Discussion	
11:45	Lunch	
12:30	Teleconference with the Associate Administrator	S. Alan Stern
1:30	Annual Ethics Briefing	Rebecca Gilchrist
2:30	Requirements for a Mars Sample Receiving Facility	Ron Atlas
3:00	Analysis Group & MOWG Reports	
	• VExAG	Ellen Stofan
	• LEAG	
	• MEPAG	Clive Neal
	• OPAG	
	• SBAG	Jack Mustard
	• CAPTEM	

	• PSS MOWG	Fran Bagenal
		Faith Vilas
		Chip Shearer
		Bill Bottke
5:00	Discussion	Sean Solomon
6:30	Adjourn	
	PSS Dinner at TBD	

4 March (8:30 AM – 5:30 PM)

8:30	Administrative Matters	Sean Solomon,
		Michael New
8:45	Report on Lunar Architecture 2 Study	Geoff Yoder
9:45	Report on Outpost Science Working Group Activities	Kelly Snook
10:15	Discussion	Sean Solomon
11:30	Lunch	
1:00	NRC Committee to Assess Solar System Exploration	Wes Huntress
		Norine Noonan Scott Hubbard Ralph McNutt
3:00	Break	
3:30	Discussion	Sean Solomon
4:30	Formulation of Recommendations & Planning of Future Meetings	Sean Solomon
5:30	Adjourn	

Appendix B

Attendees

Committee members
Sean Solomon, Chair PSS, Carnegie Institute of Washington
Patricia Dickerson, University of Texas, Austin
Larry Taylor, University of Tennessee
Ellen Stofan, Proxemy Research
Victoria Hamilton, University of Hawaii
Brian Hynek, University of Colorado
Charles Shearer, University of New Mexico
Hal Weaver, Jet Propulsion Laboratory/APL
Art Snoke, University of Wyoming
Will Grundy, Lowell Observatory
Tom Cravens, University of Kansas
Faith Vilas, MMT Observatory
John Mustard, Brown University
Lars Borg, Lawrence Livermore National Laboratory
Caitlin Griffith, University of Arizona
Michael New, Executive Secretary PSS, NASA
James Slavin, Goddard Space Flight Center
Clive Neal, University of Notre Dame
Robin Canup, Southwest Research Institute
James Head, Brown University

Other attendees
Nora Noffke, Old Dominion University
Victoria Swisher, Space Studies Board
Dwayne Day, Space Studies Board
Doug McCuistion, NASA
Michael Meyer, NASA
Michelle Minilli, Arizona State University
Nabil Boctor, Geophysical Laboratory
Dave Lindstrom, NASA
Marilyn Lindstrom, NASA
Lisa May, NASA
George Tahu, NASA
Sarah Noble, NASA
Larry Zanetti, Johns Hopkins University
Kelly Snook, NASA
Geoffrey Yoder, NASA
Dave Beaty, NASA Mars Program Office
Dom Conte, General Dynamics
Anne Kinney, NASA
John McCarthy, Orbital Sciences
Marian Norris, NASA
Cassie Conley, NASA
Carlton Allen, Johnson Space Center/NASA
Alan Harmon, NASA

Michael Wargo, NASA
Richard Kerr, Science Magazine
Sergei Ipatov, DTU
Joe McDermott, Lockheed Martin
Natasha Johnson, NASA
Dave Murrow, Ball Aerospace
Bob Richards, Odyssey Moon, Ltd.
Melissa McGrath, NASA
Mike Kelley, NASA
Gregg Vane, Jet Propulsion Laboratory
Scott Hubbard, Stanford University
Wes Huntress, Carnegie Institute of Washington
James Crocker, Lockheed Martin
Steve Price, Lockheed Martin
Jon Malay, Lockheed Martin
Ralph McNutt, Johns Hopkins University
Linda Billings, NASA
Phil Crane, NASA
Larry Nittler, Carnegie Institute of Washington
T. Jens Feeley, NASA
Taylor Dineam, WSI
Yvonne Pendleton, NASA
Joan Zimmermann, Harris Corporation

Appendix C

Presentations

1. *Planetary Science Division Update,* James Green
2. *Mars Exploration Program,* Douglas McCuistion
3. *Mars Sample Return Receiving Facility*, Ron Atlas
4. *CAPTEM,* Chip Shearer
5. *Update on Lunar Architecture,* Geoffrey Yoder
6. *Ethics Briefing for Special Government Employees Serving on NASA Advisory Committees,* Rebecca Gilchrist
7. *MEPAG Assessment of Mars Architecture/Budget*, James Head
8. *VExAG Update to PSS*, Ellen Stofan
9. *OPAG Update,* Frances Bagenal
10. *OSEWG Report*, Kelly Snook
11. *Planetary System Science/Management Operations Working Group*, William Bottke
12. *Grading NASA's Solar System Exploration Program: A Midterm Report*, Wes Huntress, Jr.
13. *SMD Status and Issues March 2008,* Alan Stern