

Meeting of the Planetary Protection Subcommittee, November 6-7, 2008

**National Aeronautics and Space Administration
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NASA Advisory Council

PLANETARY PROTECTION SUBCOMMITTEE

November 6-7, 2008

MEETING MINUTES

Catharine Conley
Executive Secretary

Ronald Atlas
Chair

Table of Contents

Welcome	3	
Planetary Protection: Issues and Status	3	
Mandatory Ethics Briefing	4	
Planetary Science Division Overview	4	
COSPAR Assembly	6	
Discussion	8	
Commercial aspects of Planetary Protection	10	
ESMD Briefing	10	
Lunar Exploration and OSEWG		12
Update on NAC Science Committee	13	
Mars Program Update	14	
Discussion	16	

Appendix A- Agenda

Appendix B- Membership

Appendix C- Attendees

Appendix D- List of Presentations

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November 6, 2008

Welcome

Chairman of the Planetary Protection Subcommittee (PPS), Dr. Ronald Atlas, addressed the committee and welcomed new members. Planetary Protection Officer (PPO) Catharine (Cassie) Conley reviewed items regarding membership and requested biographies from new members.

Planetary Protection: Issues and Status

Dr. Conley provided an overview to planetary protection (PP) issues, first reviewing outcomes from the May 2008 meeting, which had coincided with the Phoenix landing in the Mars northern polar region and hence a concomitantly high interest in Mars Sample Return (MSR), Mars Sample Laboratory (MSL) budget hits, Mars Sample Return Facility (SRF) issues, and a potential update for the Draft Protocol that will be dependent upon a final date selection for the MSR mission. To this end, improved coordination with the Curation and Analysis Planning Team for Extraterrestrial Materials (CAPTEM) had also been recommended at the previous meeting. In terms of recommendations from the National Research Council (NRC), PPS has agreed to consider more critically the implications of sample return, including social and ethical considerations. Changes at the NASA Advisory Council (NAC) were noted, with respect to a new expectation of subcommittee representation at NAC meetings. Transition issues related to the incoming administration were also of importance.

Dr. Conley referenced an earlier (2005/6) NRC study on preventing the forward contamination of Mars, which had viewed the subject in terms of what it means to humans in a nonscientific sense. Dr. Atlas reviewed PPS concerns in this respect, in particular the potential for carrying material from Earth to another planet which might interfere with future science missions, such as missions impacting areas with a high likelihood of presence of water (reactors melting ice, etc.) PPS concurs that NASA must consider implications broader than this scientific terrain. Dr. Laurie Zoloth commented in the larger arena of human philosophy, the nature of the imperial quest and planetary colonization, all of which raise extraordinary questions about duties and responsibilities to the universe, and the frailties of the physical world. Dr. Atlas added that the other side of the coin is the material returning to Earth with potential life, how to protect and detect the nature of this life, and how to protect Earth from potential harm; i.e. protecting science from itself. PPS must also consider that the NRC provides the science base and missions deriving from science considerations, and therefore those on the committee must remove their scientist's hat for considering larger questions. Any science objections must be bounced back to the NRC for resolution. Dr. Conley commented that PPS should consider whether NASA's policy and implementation strategies are in fact wise.

Dr. Atlas noted that spacecraft sterilization costs can make or break a mission, another tension PPS must consider. The committee reviewed mission categories contained within a distributed Committee on Space Research (COSPAR) handout. Specific requirements based on COSPAR mission categories cannot be ignored, but PPS can help missions meet requirements, sometimes creatively. Dr. Atlas noted a recent COSPAR change regarding the nature of cold traps at the Moon, adding that PPS may make specific recommendations about these COSPAR requirements. Mr. Greg Williams, Executive Secretary of the NAC Science Committee, commented that the NAC, indeed, would want PPS to comment on this issue. It was also noted that in practical terms, the new categorization imposes no onerous requirement other than documentation, and NASA has already judged that the new categorization would not impact any missions to the Moon. While there have been no official objections, it was felt that PPS should comment and give its imprimatur to the decision. COSPAR is merely reflecting what NASA and other agencies are doing, and does not force its views on agencies.

That said, Dr. Atlas noted that NASA and COSPAR policies do have the potential to be different. Dr. Victoria Hipkin commented that COSPAR does not provide implementation, but at a high level attempts to shepherd all agencies in terms of planetary protection. Dr. Atlas felt that PPS could either officially accept COSPAR's recommendations or advise NASA to adhere to another policy. Dr. Conley added that NASA generally will follow COSPAR, per policy. Dr. Zoloth viewed COSPAR as the international guideline that speaks to exploration as part of an international science thrust, while instructing agencies to honor the noble rather than the entrepreneurial impulse. There are also implications about taxpayer dollars- how safe is safe enough for Sample Return? Dr. Michel Viso commented that COSPAR represents itself through the scientific bodies of participating countries, and therefore the scientific will in space activities in general, in a consensual manner. Dr. Atlas re-emphasized the need for PPS to officially comment on the new COSPAR upgrade.

Mandatory Ethics Briefing

NASA legal representative Rebecca Gilchrist provided the committee's mandatory annual ethics briefing, reviewing rules for Special Government Employees (SGEs).

Planetary Science Division Overview

Dr. Tibor Kremic provided an update on the activities of the Planetary Science Division (PSD), first describing recent arrivals of new personnel including Mary Voytek in Astrobiology, and himself, a Glenn Research Center detailee. PSD continues the effort to fill other positions as well. Recent selections and opportunities in the division include the Mars Scout 2013 selection, Mars Atmosphere and Volatile Evolution (MAVEN). MAVEN is an aeronomy orbiter mission that will study solar wind interactions and Mars atmospheric escape, with mission parameters defined by the Mars Exploration Program Analysis Group (MEPAG) and NRC. MAVEN will also function as a planetary telecommunications infrastructure refreshment. In Astrobiology, 10 selections were made out of 37 proposals, constituting a good mix of new and returning principal investigators (PIs) and teams. Other opportunities include LASER and NASA Lunar Science Institute nodes (call is closed), and a Stand Alone Mission of Opportunity (SALMON) call that was released in September. A National Academy of Sciences (NAS) study, via Congressional direction, is also under way to address NASA planetary missions vs. balance in the Research and Analysis (R&A) programs. Studies on radioisotope power systems, and Near-Earth Object (NEO) issues in detection and mitigation, are being jointly run by the National Science Foundation (NSF) and NASA. NASA-directed studies are being conducted for science opportunities enabled by NASA's Constellation system, and Planetary Protection for MSR. NASA is also in the process of preparing its charge to NAS for the next Planetary Decadal Survey, which is also being prepared in tandem with NSF; the task is to be delivered to the NAS by end of the year. The Decadal Survey task will cover a general overview of planetary science, the current state of knowledge, important guiding questions, balance of mission sizes, high-value technology development needs, a prioritized list of major flight investigations, and supporting research to maximize science return from flight investigations. The task will include the Solar System, Moon and Mars. Extrasolar science will be covered in the Astrophysics Decadal Survey. Dr. Zoloth asked whether ethical and social issues would be considered, and Dr. Kremic took an action to confirm this. Dr. Conley added that PPS had previously recommended such issues for coverage in the survey.

Planetary Mission Status

A New Frontiers competition is being prepared (medium class \$700-800M), which will be an open competition for strategic missions, a hybrid between PI-led and directed missions. A draft Announcement of Opportunity (AO) is in progress, and will be posted for comment for 3 months after release. This announcement will mark the first use of a standard AO for PI-led missions, and should help streamline the process for future AOs. The AO will be following recommendations 1 & 2 from the Space Studies Board (SSB) New Opportunities in Solar System Exploration (NOSSE) report. New Horizons was launched in January 2006 and is en route to Pluto and the Kuiper Belt. JUNO, a Jupiter Polar Mission has been confirmed for an August 2011 launch. A third New Frontiers AO will

contain missions surrounding sample return and network science. The timeframe for the third AO is NET 2016 for launch. PPS expressed the intent act on these missions after their selections.

Dr. Kremic reviewed the Discovery program (small missions; \$350-400M). MESSENGER has had its second flyby of Mercury at an altitude of 200 km, in early October. DAWN is getting ready for a Mars gravity assist as it travels to the Ceres and Vesta asteroids. A preliminary design review (PDR) for the Gravity Recovery and Interior Laboratory (GRAIL), a lunar mission, will be held in the near future. A Discovery Scout Mission Capability Enhancement effort is under way to examine how a radioisotopic source/Stirling generator might enhance missions to Venus, Moon, Outer Planets, and comets, and how they might be used in landers, sample return vehicles, etc.

Outer Planet Flagship studies are also under way. NASA and the European Space Agency (ESA) are running joint studies, with a presentation due to NASA/ESA in January 2009. One Flagship mission will go forward in 12-14 years as a joint effort. Asked to define "sweet spot" science, a term recently introduced by Science Mission Directorate Associate Administrator Ed Weiler, Dr. Kremic explained that it meant softening budget boundaries to try to accommodate science restraints, resulting in a comparison of bare-bones, medium return and "Cadillac" missions, and using these categories to determine the best value. The intent of the sweet spot concept is to get the community to think about how much use can be made of the available budget. EPOXI is a follow-on to the Deep Impact mission (using an existing spacecraft), and will be traveling to comet Hartley. Another comet mission will use the Stardust spacecraft (Stardust NEXT). These missions had already been adequately categorized, and so did not come before PPS a second time.

Lunar program

The Indian spacecraft Chandrayaan launched on October 22nd (with a U.S. instrument on board). Other lunar missions in development are the Lunar CRater Observation and Sensing Satellite (LCROSS), Lunar Reconnaissance Orbiter (LRO), GRAIL, Lunar Atmosphere and Dust Environment Explorer (LADEE), an extended Time History of Events and Macroscale Interactions during Substorms (THEMIS) mission, and an International Geophysical Network (ILN).

Mars and Mars Science Laboratory

The Mars rovers, Spirit and Opportunity continue to function well beyond their baseline mission parameters. The Phoenix lander is getting very cold while the Mars Reconnaissance Orbiter (MRO) continues to communicate with it. Temperatures at the Mars north pole are expected to drop to -140°C, therefore Phoenix is not expected to survive the Martian winter- CO₂ frost could build up to a meter in thickness, in which case the lander's solar panels are likely to break off. MRO has been extended to about 2018; it will image Phoenix as the ice builds up.

MSL challenges are considerable. The mission was confirmed at \$1.6B in August, and still requires \$223M to meet the 2009 launch. It is likely that the program will have to spend even more. There is another launch opportunity in 2011, but it would require many more resources. The Administrator still supports a 2009 launch, but the total overrun and strategy will be reviewed by the Office of Management and Budget (OMB) and Congress. There are no cost issues from a Planetary Protection standpoint. MSL is a category 4a mission, and meets the 300-spores-per-square-meter-surface-exposed-to Mars requirement (Viking standards). Using adenosine triphosphate (ATP) counts, it is clean enough to meet standard assays. A participant added that Limulus Amebocyte Lysate (LAL) and ATP assays are used at the project's discretion as a go/no-go until the standard assay is finished; LAL and ATP assays are not used to demonstrate compliance. Dr. Zoloth commented requirements should reflect the newest technologies. A participant commented that changes were certainly likely as assays increase in sensitivity, and that standards must be re-evaluated periodically; however, the current requirement reads that if a life detection instrument yields more sensitive results than those required by Viking standards, then NASA must adhere to that greater sensitivity. Dr. Colleen Cavanaugh noted that it is clearly better to use chemical/lipopolysaccharide (LPS) assays than to use

culture rules. She added that as sterilizing and autoclaving does not eliminate DNA, polymerase chain reaction (PCR) techniques could detect DNA on non-UV treated craft. Dr. Atlas recommended that PPS discuss the possibility of asking the NRC to initiate a study on the potential need for new standards.

COSPAR Assembly in Montreal 2008

Dr. John Rummel gave an overview of COSPAR's recent proceedings, in the context of a brief history and description of policy process. COSPAR first published an official policy in 1963, and since that time has tried to reflect international consensus on planetary protection. COSPAR recommendations derive from requests from space agencies, the United Nations, scientific commissions, and COSPAR leadership, among other sources. In Montreal, COSPAR evaluated the most recent incoming resolutions, which are then considered by the elected COSPAR Bureau, (the US is represented by the NRC on this bureau), and thereafter the COSPAR Council. The Council then votes, and the Planetary Protection Panel makes the change if there is sufficient agreement.

Dr. Rummel reviewed the most recent resolutions considered for Bureau action. The first involved the use of Viking terminology (information only), followed by various other subjects:

COSPAR made some minor language revisions in its policy statement on the likelihood of life elsewhere in the universe, dropping the "rarity" phrase, and a revising a reference to interplanetary missions. In the definitions of special regions on Mars, COSPAR added physical terms as descriptors, including limits for water activity, temperatures, and timescales in which limits can be identified. Potential sites for special regions include gullies, bright streaks, pasted-on terrains, subsurface below 5 m, and other areas to be determined, including dark streaks and possible geothermal sites, fresh craters with hydrothermal activity, etc. Spacecraft-induced special regions are to be evaluated on case by case basis, however no special regions are currently identified by COSPAR. In response to a question regarding no mention of now-dry lakes, Dr. Rummel responded that these regions seem to have been ruled out by the rovers' activities.

Venus has been assigned a Category 2 designation because of interest in Venus as source of complex clues related to the origin of organic molecules in the universe. The new categorization adds no requirements to missions, per se. As Venus has always been Category 2 in NASA policy, the COSPAR resolution is regarded as merely tidying up policy. Within COSPAR, the Moon is also regarded as Category 2. PPS may want to revisit these nominal changes as a matter of course, however.

The Moon has also been newly designated as a Category 2 destination within COSPAR. The Category 2 requirement for robotic lunar missions came about based on potential destruction of polar volatile deposits/evidence by impacting craft, imported volatiles emanating from rovers, etc. Therefore COSPAR is asking for a listing of organic inventory for these missions. Dr. Zoloth asked if there were a mechanism of enforcement for these rules, citing 2007's Chinese military satellite incident that created a significant debris cloud. Dr. Rummel noted that there is no enforcement arm of COSPAR, and that compliance was generally based on goodwill amongst COSPAR parties and the practical consequences of non-adherence. A brief discussion ensued regarding NASA's internal controls on COSPAR policy, and PPS was satisfied with NASA compliance. PPS discussed the level of detail covered by organic inventory requirements and noted COSPAR's current lack of requirements for human lunar missions. Dr. Rummel noted that NASA's Office of Safety and Mission Assurance (OSMA) requires that any mission that impacts the lunar surface must have the approval of PPO and OSMA.

Broad participation in Panel Activities

COSPAR recommended that nations involved in space missions should identify a COSPAR associate to serve as their liaison with the COSPAR Planetary Protection Panel to increase involvement in policy development, and to ensure consensus.

Human Exploration of Mars

COSPAR has revised its policy on principles and guidelines to include safeguarding against back contamination of Earth as its highest priority for Mars exploration. Human-associated contamination must be controlled and understood, while recognizing that an entirely closed system is not possible. Thus implementation guidelines should include provision against backward and forward contamination, quarantine capabilities, development of a comprehensive Planetary Protection protocol, such that neither robotic nor human activities should contaminate special regions on Mars. Any site should be evaluated by robotics before humans are sent to investigate. Any pristine samples from special regions or uncharacterized sites should be treated according to Category 5 designations (restricted Earth return). Essentially this category means that humans may land on the surface of Mars, but cannot venture out without a precursor mission, or a lander arm, or a rover to check for deleterious matter/life. PPS noted that many would argue that these requirements would lend an encumbering cost to missions. Dr. Rummel commented that as humans carry their own extant life, they should not be placed in special regions as guinea pigs, lest they themselves contaminate special regions (and vice versa). An onboard crew member would ideally be designated PPO as a matter of local control. Planetary Protection guidelines in developing requirements should err on the conservative side until sufficient information is attained to make alternative decisions.

COSPAR will be holding workshops in early 2009 to address Outer Planet exploration, update knowledge, and to focus on the protection of Europa. Dr. Viso reported briefly on a workshop at the European Commission on Outer Planet satellites, where he would be reporting on planetary protection issues; he noted also that an ethical workshop was in progress. Dr. Budden commented that new COSPAR guidelines seem to lean toward more precursor missions. Dr. Rummel replied that COSPAR's language was broad but consistent with NRC's Safe on Mars report. The last three missions indicate that Mars has much variation. It is still not clear how long a quarantine might be required for Mars missions. There have been past recommendations for an in-situ medical monitoring system to indicate exposure to novel species. Added to the complicated mix is that precursor sampling from Mars cannot possibly be exhaustive due to very limited opportunities. It is not clear at what point science will accept when and if sample evidence is enough. Dr. Margaret Race commented that all the workshops agree that sample return is critical, while NRC has grappled with biohazard indicators and has settled on replication as the decisive parameter. Dr. Zoloth asked if "weird life" were acceptable to bring back to Earth, and that only organisms able to replicate in the human environment would be considered dangerous. Dr. Rummel referred to Joshua Lederberg's observation that while weird life may never be detected by our systems, there is no guarantee that such undetectable forms would not be harmful to terrestrial life.

Discussion

PPS accepted, by consensus, COSPAR's categorization of the Moon, assuming that NASA already maintains an organic inventory as described under the COSPAR guidelines. Dr. Conley noted that Goddard Space Flight Center (GSFC) is already considering human missions, and is documenting where other human missions have gone. Dr. Pieters commented that lunar polar areas are potential volatile traps, and that NASA is not the only player in this area, which raises the visibility of the science question for all other space agencies on the Moon. Every craft that orbits the Moon will crash into the Moon, with implications for interesting areas. Requirements for human missions were deferred to the next meeting, to be contemporaneous with a Safe on Mars briefing.

Ethical Legal and Social Implications of Planetary Protection

Dr. Race reported on recent ethical and legal considerations of planetary protection as conducted at NASA, addressing the question: What is life and how do we treat environments? Issues beyond the scientific question have emerged over the years, beginning with Hargrove's 1986 Environmental Ethics and Spaceship Earth document, followed by various papers in the 1990s on ethical and theological implications of extraterrestrial discovery, ESA's Ethical Working Group, ESA's Legal

Issues on Planetary Protection and Astrobiology (2004), and a ESA-EWG workshop on the Legal and Ethical Aspects of Space Exploration, originally proposed in 2004 by UNESCO. In 2006, NASA asked NRC to consider forward contamination of Mars, from which came the report PREVCOM (Preventing the Forward Contamination of Mars) in July 2006. PREVCOM's first recommendation went beyond typical science and policy scope, to wit; to reconsider the rationale for planetary protection in light of uncertainties about planetary environments and microbial life. These efforts led to an international workshop to consider whether planetary protection policies should be extended to include rights of other explorers, to explore Mars in a manner considerate of possible life, to consider revisions of policies, and to involve public in the dialogue.

Planetary protection is rooted in the Outer Space Treaty of 1967, which imposes international obligations to preserve the Solar System and includes over 90 signatories. Recent historical interpretations have led toward biological considerations in mission timelines and orbit configurations for spacecraft. During this period of more missions and capabilities, planning for sample return facilities and human exploration on Mars, a coherent policy has become necessary. There is currently no policy for the discovery of microbial extraterrestrial life, with lingering questions about uncontrolled interactions with planetary environments. Private sector efforts are also under way, such as the Google X Prize competition for a commercial landing on the Moon. The X Prize offers a \$5M bonus for landing at an Apollo site. Of concern is the fact that private companies are not required to provide environmental impact statements.

Other fields actively regard life and environment interactions (e.g., synthetic biology, genomics, artificial intelligence, and robotics). These considerations have been vetted by the COSPAR Bureau, and have led to the call for an international workshop conference, likely to occur in 2009/10. Lawyers and other nonscientific experts will be involved in this workshop. Policy implications on science, life and environment, and all Solar System bodies must be considered judiciously. The workshop will compare existing policies, examine perspectives on microbial life vs. human and other higher life forms, speculate about environments with and without life, consider what to do upon life discovery, determine short- and long-term policies upon confirmation of such life, determine concerns, and build on earlier analyses and analogues. Current treaties do not all address preservation and conservation of living resources. The adequacy of current planetary protection policy in protecting different features during exploration must be carefully assessed.

Interim findings, by authors Race and Randolph, are in progress. The paper addresses a defensible scientific approach to date, adequate policy during the search phase, large-scale impacts on environments, human missions, and private sector activities. Next steps are to prepare for the COSPAR workshop. In preparation, a workshop will be held at NASA's Search for Extraterrestrial Intelligence (SETI) Institute in February 2009 to discuss the legal and ethical, cultural, and theological implications of the search for life, origin and evolution of life, and life as we know it or don't know it; 35 participants are expected. Workshop results will be actively disseminated and feedback invited. Another workshop is planned, pending funds, for 2010 to address environmental issues in the lunar area.

Dr. Zoloth invited PPS to pay serious attention to these issues, noting that there is a very real impulse to make money off the Moon, and to use it militarily: What's the difference between scientists breaking off a piece of the Moon vs. a commercial enterprise? Dr. Viso commented that the launching state has the responsibility to police and consider these issues, and bears the liability, as does the state that purchases the launch. Dr. Zoloth asked: what if they don't care? Dr. Cavanaugh noted that an analogous activity on Earth is the selling of leases on the ocean floor near Tonga and Fiji, to mine minerals around hydrothermal vents. Dr. Doran cited the LunaXhod idea, promulgated by Russia, for remotely coring samples on the Moon, advertised as a children's activity. Dr. Atlas asked if PPS was to become an historic preservation committee, in addition to its planetary protection charter, as scientists have been most influential in terms of policy until the present time.

There was a brief discussion of PPS' role in historical preservation, with some members asserting that other agreements, such as the Outer Space Treaty, confers relevant liability upon commercial enterprises. Dr. Mary Voytek commented that preservation might be redefined as a cultural effort, likened to preserving prehistoric middens at archaeological sites; this consideration would seem to fall within planetary protection. Dr. Race commented that the Antarctic treaty has evolved in this fashion, despite violations such as the taking of meteorites. Dr. Zoloth advised PPS to look beneath the jocularity associated with "footprints on the Moon", as these values shift continually. Can discovery be done differently and more ethically? How much is it really worth? What is sacred to us?

Dr. David Carrier felt that PPS should not expand its charter, while still recommending that some individual at NASA address these issues, such as a 5-km standoff radius for each Apollo landing site. There have been recommendations to reexamine Apollo sites for scientific purposes, however. Dr. Gerhard Schwehm commented that UNESCO has some rules that could be taken advantage of for site protection concerns.

Commercial aspects of planetary protection

Dr. Conley reviewed the essential planetary protection policy for the benefit of new members. She referred to the emplacement of policy and implementations as embodied in NASA Policy Directive (NPD) 8020.7F, has just been submitted for revalidation.

Dr. Conley reported on recent interactions with the Federal Aviation Administration (FAA) and other agencies for the purposes of coordination. NASA is currently seeking FAA representation on PPS, as a means of exerting better influence on commercial launches. Agencies that seek to use NASA assets must comply with NASA Planetary Protection Policy. Commercial launches are licensed by the FAA, as a function of the major shareholders of the company and the country from which it is launched. These licensures cover a US-owned company or companies predominantly owned by the US, or a foreign company launching from the US, (if it is utilizing US insurance coverage). FAA provides a maximum probable loss estimate and oversees the terms of such insurance. The US indemnifies against damages beyond the purchased insurance. It is possible that PPS could feed into this type of insurance consideration. FAA is still in discussion on other types of jurisdictions. There may be possible legislation on the intersection of the civil and commercial sectors in this regard, as well. Dr. Atlas suggested that PPS revisit this subject at a future meeting, with legal advisors present.

FAA is mandated by Congress to regulate against dangers to public, and holds regulatory authority for protecting the environment, but not beyond launch or reentry. The FAA considers the safety review performed by NASA during an interagency review period, which is a possible influx point for Planetary Protection. Dr. Voytek expressed concern over how to deal with those who would circumvent regulations. Dr. Conley replied that FAA has jurisdiction no matter where the US company launches. Dr. Andrew Steele commented that the private sector should be educated, and that introducing planetary protection concerns to commercial launch companies would be ideal. Dr. Conley added that NASA cleanliness standards may be relevant for bioterrorism assessments, and thus may be of service to the Department of Homeland Security.

At the end of the discussion, Dr. Atlas extended his thanks to the departing Dr. Zoloth for her participation in PPS and wished her well.

November 7, 2008

ESMD briefing on human exploration

Dr. Marguerite Broadwell gave an overview of the Exploration Systems Mission Directorate (ESMD) status in terms of human exploration activities. ESMD contains the Advanced Capabilities Division,

further subdivided into the Lunar Precursor Robotic Program, Human Program, and Technology Program. ESMD also includes the Commercial Crew Cargo Program, and the Constellation program (primarily vehicles). ESMD tends toward center-heavy activity.

Dr. Broadwell reviewed the rationale for a return to the Moon, in terms of its importance to human civilization, scientific knowledge, preparation for exploring Mars and beyond, public engagement, and global partnerships. The notional timeline provides for the retirement of the Space Shuttle in 2010, followed by the development of Ares I to carry the Orion crew capsule to the Moon. There will be a 4-5 year “gap” period due to budget restrictions. Ares I and Orion are well into the design and development stage. Elements of an outpost lander and ascent vehicle, rover, science laboratory and habitat, and in-situ resource utilization (ISRU) are also being developed. NASA is not expected to provide all of these capabilities. While the lunar program, by mandate, needs to enable economic expansion and include international partnership, and national security concerns, NASA expects to continue its key role in space by maintaining good international relations with other space agencies. In 2007-8, the International Space Exploration Coordination Group was developed and is working together to support these goals.

Science research and collaborations in support of lunar activity include NRC’s Decadal Survey for Life and Microgravity Sciences, which is currently in progress. A NASA Lunar Science Institute is forming, and 33 proposals are being evaluated with ESMD and SMD funding. An Optimizing Science and Exploration Working Group (OSEWG) has also been formed to vet lunar exploration efforts.

Constellation Program

Initial capabilities within the Constellation program are the Ares I launch vehicle, Orion crew capsule and extravehicular activity (EVA). Future capabilities will include the Ares V launcher, which will carry the Altair lunar lander.

Lunar Exploration/OSEWG activities

The lunar architecture plans for sending cargo to the Moon first, with humans to follow. Constellation is building upon a foundation of proven technologies, including solid boosters and some upper stage configurations. Dr. Atlas asked if the program was going to face the same problems with its solid rocket boosters (SRBs) as it has in the past. Dr. Lindberg commented that since 1986, SRBs have not been problematic. The challenge faced today is early launch abort/escape capability for the crew. The Ares system is being designed to allow the crew capsule to be pulled away from the launch vehicle, possibly even while still on the launch pad. There is some discussion as to whether the Orion capsule can be re-used, as well. A participant commented that because Ares V can also lift more payload than a Saturn V, discussions are under way to use the larger Ares vehicle to launch very large telescopes. Crew would never fly on an Ares V, therefore both Ares I and V will be required to return to the Moon.

The Altair Lander will be capable of landing 14-17 metric tons (mT) of cargo. A lunar architecture requirement originally envisioned 100 kg of sample return; this has been changed to a “stretch goal” of 250 kg per trip. The anytime-return requirement makes it difficult to bring back larger amounts, as a great deal of fuel is used up to compensate for the precessing movements of orbital bodies. Engineering trades are being made to judge where the science needs fit in. A crew of 4, with everyone going to the surface, is one scenario. Another option is to send fewer people to the surface in order to bring back more sample. The architecture is also considering leaving robotic satellites unattended for long periods, but the gravity field of the Moon must be measured in greater detail before this can be accomplished.

Constellation is already testing a ¼-scale crew module. A water landing for the return to Earth is the baseline plan for the crew module, but a land return plan is still being worked as a backup. Major acquisitions to date include the Orion contract award in August 2006, a Broad Agency Announcement

(BAA) for the Altair Lunar Lander, which will have a phase I design support RFP release in February 2009. A BAA for Lunar Surface Systems, including such concepts as energy storage, compact/edible packaging was made in July 2008, with completion for concept development due in February 2009. NASA is also working with US Chamber of Commerce to get industry involved in the effort. There will be a three-day workshop November 24-26th to outbrief on these areas, and NASA hopes to task industry in some pro bono collaborations. EVA systems experienced a protest on a space suit award, which caused a termination, but the proposals will be re-competed. Dr. Lindberg asked if Ares V would be large enough to support Mars Sample Return (MSR). Dr. Conley replied that MSR would be a consideration for Ares V.

Dr. Broadwell reviewed progress in other areas of lunar preparation. GRAIL in 2013 will be the “Cadillac” mission for mapping the lunar gravitational field. LRO is currently in thermal vacuum testing, and will be ready to launch as soon as a launch vehicle becomes available (April 2009), and will also contribute to the lunar mapping effort. The Exploration Technology Development Program is working on pressurized rovers and composites, analogue testing at Blackpoint Lava Flow, and is studying how to perform ISRU with rovers. Dr. Broadwell distributed handouts to demonstrate the original size of the Apollo rovers and greatly enlarged new designs. A small pressurized rover and the larger Chariot use the same chassis to save costs. Dr. Lofgren commented that NASA is also examining a new concept: a Segway-like vehicle that takes the weight of the suit off the astronaut, and thus gives more flexibility for EVAs. Distance is still an issue, but the rovers in development can go farther than the Apollo rovers. The rovers can also be driven remotely from Earth. Airlocks have been developed to allow ingress/egress into the habitat module- the process takes about 20 minutes. Leakage rates have yet to be determined for this activity. Dr. Gordon Johnston commented that important to realize that these designs are in the concept stage, thus the community has ample opportunity to influence requirements and inject science considerations where necessary. Dr. Broadwell agreed with this assessment, adding that the technology development program is focused on working with other agencies to further progress, and is preparing for a large push with elements of the Department of Defense (DOD) and the space sector. She summarized by citing the major work in progress while staying within budget constraints. Budget is the scope, and schedules will be extended to mitigate funding shortfalls. Dr. Steele asked if requirements were in place for in-situ microbial monitoring devices on crewsuits, for the control of forward contamination. Dr. Johnston replied that while this is not known, surface scenario teams are working on this very issue, and it is a good place to inject planetary protection concerns. Dr. Broadwell noted that no official requirement has yet been submitted for the suit in terms of in-situ monitoring.

Lunar Exploration and OSEWG Activities

Dr. Johnston provided an overview of OSEWG activities in the realm of lunar exploration. OSEWG was chartered in 2007 with an initial focus on “Outpost” science, and was tasked with coordinating and guiding science and exploration planning, including all science involved with human health, sortie and orbiter activities, with science objectives provided by the NAC, NRC, MEPAG, LEAG, etc. OSEWG was also chartered to serve as a liaison to the Lunar Exploration Analysis Group (LEAG) for SMD and ESMD. OSEWG is focused on defining science and exploration objectives through the Surface Science Scenarios Team (SSST). Dr. Johnston noted that Dr. Conley is also on the OSEWG. OSEWG coordinates ultimately science requirements for inclusion into the Constellation architecture. Dr. Pieters asked if any consideration was being made of including cargo and crew in the same vehicle. Dr. Johnston replied that this would require development of an entirely separate system, which may be worthwhile if the ISRU scenario pans out. OSEWG has initiated a joint LEAG/CAPTEM study on sample curation and related matters; leaving caches of samples stored on the Moon is one scenario being considered.

OSEWG is firming up plans for the transportation system, but sizes of habitats and laboratories are to be determined in the near future, thus the next 14 months will be an ideal time to inject science considerations, after which serious planning and design will take place. To this end, OSEWG wishes to

engage the NASA and non-NASA science community in developing lunar science priorities, objectives and requirements, and to leverage existing conferences and entities. (website: www.lpi.usra.edu/osewg). The OSEWG Implementation Plan is due to be finalized within the next 90 days, and plans are also under way to coordinate ESMD, SMD, NLSI, LEAG, and CAPTEM leaders on how to best deal with the community. Recent accomplishments include the completion of a revised OSEWG charter, and the first SSST workshop. New hires have been made to help implement OSEWG strategy, and OSEWG has developed an initial action plan to respond to input and address science objectives.

Dr. Johnston reviewed SSST key activities, such as developing Apollo-like sortie missions, longer traverse missions at multiple sites, multi-mission polar outpost concepts and 3 sortie mission concepts. The team is also working on landing site selection, science architecture and Constellation Operations, sample acquisition and curation, reduced gravity and life science concepts, and the definition of integrated science payloads. Science productivity metrics are being developed as parameters for evaluating options. Dr. Johnston requested assistance in incorporating planetary protection into these scenarios, and to consider them in light of the Moon as a preparatory stage for Mars exploration, beyond the current level 0 planetary protection requirement.

Sampling and curation recommendations are also being processed by the OSEWG, seeking an optimum state between science and integrity of sample, sortie vs. outpost sampling, and consideration of facilities on Earth. OSEWG has established the Lunar Sample Acquisition and Curation Team, with a first phase report to be finalized in October 2009, followed by second and third phase reports dealing with protocols/assessment, and curation at Earth, respectively, by the end of 2010.

The 2007 Tempe lunar architecture meeting yielded 6 planetary protection recommendations, including development of contamination control technologies, and improving life support systems to minimize leakage. NASA has responded to these recommendations and is planning a workshop in Spring 2009 at the Ames Research Center. A workshop with ESA will be held, which will consider Mars Sample Return as well. Results of these workshops will be fed into instrumentation and protocol development, followed by validation via analog/field testing. In response to a question about novel curation ideas, Drs. Lofgren and Johnston described an effort to modernize the Apollo analytical systems, adding curation on the Moon as an entirely new concept. Communication and optical connections (video), an XRF device for real-time analysis, modernized documentation processes, etc. are also being considered. Dr. Pieters suggested the use of spectral instruments for in-situ examination of lunar geology. Dr. Johnston noted that the Earth Sciences Subcommittee (ESS) has recommended that instruments be set up on the Moon to look toward Earth. The Astrophysics Subcommittee (APS) has also recommended protecting the long wavelength spectrum and is considering establishing networks on the radioquiet dark side. Dr. Steele commented that sample collection will be governed by the science, but biochemical/planetary protection assays will be a headache; one must guard against providing a habitat for a life form to grow and mutate. Dr. Lofgren suggested PI oversight on these issues. Dr. Atlas suggested that PPS make specific curation recommendations re: Moon/Mars to test the viability of organisms.

Update on Science Committee

Dr. Conley reported on recent administrative changes on the NAC and the upcoming administrative change, noting that subcommittee representation at the NAC Science Committee has been requested by the new Chair of the Science Committee, Dr. Jack Burns. Dr. Carrier reported attending the second day of the NAC's recent two-day meeting which was devoted to generating white papers for the next President and NASA Administrator, defining the one big question that each Subcommittee addresses. As PPS is devoted more to engineering and standard-setting, a useful question for PPS might be: where does/might life exist in the Solar System? Dr. Conley crafted and distributed a PPS white paper for this purpose, which is now a useful document. There is some interest in whether the

NAC will be restructured. Currently there is a variety of opinion on the usefulness of the current NAC structure. Mr. Williams commented that the NAC serves at the pleasure of the Administrator, and structural changes were uncertain. Dr. Atlas felt that Dr. Burns would invite more direct subcommittee involvement in the NAC Science Committee, if the structure remains the same. Mr. Williams noted that NASA needs to retain PPS expertise in some form, but that ultimately this is a NAC/Administrator decision. He predicted that many months would transpire (Spring/Summer 2009) before matters would be finalized. In the meantime, the transition team's visit to Headquarters provides an opportunity to point up the awkward position of PPS and how it might be improved.

Dr. Jon Miller commented that chances are that short-term NASA policy will be coordinated at Congress. In response to a question regarding the information pathway to the transition team, Mr. Williams replied that one formal path is through NASA's Program Analysis and Evaluation (PA&E) office, which has the task of characterizing the status quo without prejudice. The other path is bringing items of content through the SMD front office, which may be the most effective approach as its occupants will outlive the transition. Dr. Conley remarked that functionally, the recommendations of PPS do find their way to the SMD front office; the issue is that the NAC might potentially inhibit the functions that NASA needs from its subcommittees. Dr. Faden commented that the current structure does seem questionable and asked whether PPS should identify principles in directing advice, so as to not allow formality to undermine a necessary function. Dr. Race noted that a 1992 forward contamination study by the NRC suggested that PPS be separated from the Science Committee, because its presence within the NAC represents a conflict of interest. Dr. Atlas indicated that any filtration of PPS message could be problematic, noting that ESA Planetary Protection is held outside the program directorates, and it reports directly to the Director General and the ESA Council. Mr. Williams commented that while the current Administrator has requested integrated advice, such advice doesn't work where the subject matter is more regulatory in nature; regulatory advice cries out for a separate and independent body. Dr. Carrier cited political suppression of an ESS subcommittee white paper as a cautionary tale.

Mars Program Update

Dr. Michael Meyer provided an update of the activities in the Mars program, in which all but MSL is going smoothly. The Phoenix lander has provided unprecedented imagery, detected H₂O sublimation, and has imaged exposure of water-ice in the permafrost. Its LIDAR instrument has detected dust storms and streaks of virga in the atmosphere. The lander has confirmed the presence of perchlorates in soil, hygroscopic oxidants that may be contributing to soil stickiness/thickness. Perchlorates can conceivably be used by some bacterial species (chlorate-respiring). As of sol 161, the craft is getting colder and is showing signs of shutting down. In response to a question, Dr. Meyer explained that the perchlorate was generally not felt to be an exhaust product, most of which was likely outgassed in transit. As there is no organic sample to compare it to, there is no real evidence that it is contamination. Dr. Hipkin noted that as perchlorates have been found at the surface and subsurface of Mars, a recent analysis has shown that the trace amounts are too low to have been brought in by the spacecraft, and furthermore that perchlorates do exist in very dry terrestrial deserts.

Mars Odyssey has detected chlorides, and the program is moving the craft to an earlier orbit time to search for deposits with a better signal-to-noise ratio. The Opportunity and Spirit rovers are still functioning, and are traversing plains. MRO has revealed detailed layers at the polar cap, which contain few depressions, implying the presence of a thicker crust, which in turn implies less tectonic activity. The findings have sparked some debate; some feel that the perchlorate's effect on freezing/melting points may contribute to the explanation. The MRO Mars Climate Sounder has also revealed global dust storms, and dust heating in the atmosphere. The HiRISE instrument has imaged opaline material (hydrated silica) with a long-standing water association.

Despite budget problems, MSL instruments are being delivered, and flight cabling and avionics are being installed and tested. The sample cache has been removed in response to community opposition, representing a \$2M investment. MSL is still on track for a 2009 launch. The program took the opportunity to inventory microbes of the cache, in a cleaning process that was originally meant to reduce the noise level. For planetary protection purposes, in terms of microbes, the cleaning procedure would probably have had to have been more stringent if the cache had been included. Dr. Conley noted that a sample return mission is by definition life detection, so the procedure indeed would have been different. The committee discussed the implications for sample treatment, noting that the cache would have required encapsulation of samples. Dr. Steele commented that the original cache design had limited segregation abilities, and would not have enabled anything more than confusing science. Dr. Conley agreed that while the particular implementation was a bad idea, it sparked thought on improvement. NASA will have another review in January to determine the go-forward strategy for MSL.

MSL is carrying a radioisotopic thermoelectric generator; its rover will be lowered from the craft by a bridle device. The payload includes MARDI (a descent imager), ChemCam (laser spectroscope), MAHLI, Mastcam (a stereoscopic, focusable, multiwavelength camera), RAD (radiation monitoring), SAM (gas chromatograph/mass spectrometer, capable of detecting O isotopes, CH₄), CheMin (x-ray fluorimeter), and DAN (neutron detector). Of 7 landing sites, Holden crater, Eberswalde, Nili Fossae trough, S. Meridiani, Gale, Mawrth Vallis, and Miyamoto crater, all showing history of water, Nili Fossae, Miyamoto and S. Meridiani have been eliminated. Eberswalde may be eliminated due to potential rockiness, although Holden and Eberswalde still in contention as they may be reachable with one rover. While Nili Fossae is thought to contain methane, MSL's instrument, PLS, will sense it at parts per trillion sensitivity if it is on the planet. None of the chosen sites has opaline material.

JPL is expected to request another \$100M, possibly initiating a Congressional Stop Work order. Slipping the launch to 2011 will cost another \$300M, thus the most economical solution is to pursue a 2009 launch. The Mars program has exhausted all its funds; if MSL slips, funding will be taken from a JPL mission.

MAVEN, the Scout aeronomy mission, has been selected to launch in November 2013. ExoMars, a 2016 lander, will carry two major instruments for measuring organics. The Phobos-Grunt mission is in phase B but in the 2009 launch queue, which is problematic. The mission is not intended to detect life as the landing ellipse is large. Cosmic rays alter organic matter, and it is not clear whether an effective analysis can be made during this mission. Future work is going forward in a comparative planetary climate initiative, evaluation and assessment of priorities for 2016 opportunity, an assessment of outcomes of the Mars Architecture Tiger Team (MATT), and the next MEPAG meeting in March 2009.

The next decade for Mars exploration, 2018 and beyond, is currently under review. Dr. Atlas reiterated the PPS stand on the need for 10 years advance planning for a Mars SRF. Dr. Meyers replied that as sample return cannot be achieved in 2018, this will not be an issue. Technology development is also suffering from a lean budget. MSL is currently the biggest driver for future missions.

Life potential on Mars has increased, due to recent discoveries, and this will change the tenor of the future Mars program. Modern life may still be possible (indicated by possible presence of methane). There is also evidence for early Mars climate change, as indicated by the cratering rate, and layered patterns in the polar cap. MATT is examining the options. MSR is at least a two-element mission, requiring some combination of lander/rover/ascent vehicle, and orbiter/capture/return. If there is no MSR in 2018, NASA plans to substitute a Prospector rover in 2016-18. The program can still plan for a lander that would feed forward to MSR. Out of all the options, 2020 seems to be the best opportunity for starting the MSR sequence. Science priorities for 2016 are just starting to be

examined. Money for instrument development is tentatively recognized a \$50M per year commitment. The program is also looking at scenarios that separate MSR elements to a degree that one could redevelop a system in the interval of recovery from failure. MSL-level EDL systems are currently thought to be capable enough for MSR. In summary, the Mars Program is extending the Follow the Water philosophy while trying to communicate how difficult it will be to find a fossil on Mars. Dr. Steele commented that it would be easier to focus on an abiotic environment that is analogous to early Earth, as this cannot ever be done on Earth; there are ancient rocks on the Mars surface that would provide valuable evidence.

Discussion

PPS discussed and wordsmithed recommendations regarding COSPAR's characterization of the Moon, protection of historical sites on the Moon and prevention of damage incurred by exploration efforts, microbial monitoring, and reporting structure of the subcommittee. PPS moved to make PPO a full-time position, and to request that a history of its recommendations be made available to the new NAC chair. PPS agreed to circulate the recommendations, and voted to accept the principle of all 6 recommendations in the meantime.

Dr. Lindberg suggested, in the context of recommendation 2, that LCROSS may be a violation of lunar site preservation, and asked that PPS be given a parts inventory, as well as what volatiles may have been deposited at cold traps. Dr. Conley noted this as a request for the next meeting agenda.

The committee deferred settling on a specific meeting date, subject to the plans of the NAC Science Committee. Dr. Voytek recommended PPS make a statement about the composition of the Science Committee, specifically requesting that unconflicted individuals with a broad background be appointed to it. Dr. Meyer felt that in the past, the individuals, not rules, prevented their appointments. Dr. Atlas noting that this occasion may mark his last meeting, adjourned for the day.

Appendix A Agenda

Planetary Protection Subcommittee Agenda

NASA Headquarters, Washington D.C.

Meeting of the Planetary Protection Subcommittee, November 6-7, 2008

November 6, 2008
Room 6H45

9:00am	Welcome, Introductions, Orientation	Ronald Atlas, Cassie Conley, logistics
9:30am	Planetary Protection: Issues and Status	C. Conley
10:00am	Mandatory Ethics Briefing	Rebecca Gilchrist, NASA HQ
11:00am	break	
11:15am	Planetary Science Division Overview	Tibor Kremic, HQ
12:15pm	lunch	
1:15 pm	Update on COSPAR Scientific Assembly	John Rummel, ECU
2:15pm	Discussion	R. Atlas
3:00pm	break	
3:15pm	Update on ELSI: workshops and other activities	Margaret Race
4:15pm	Interactions with the commercial sector: preview of day 2	C. Conley
4:45pm	Discussion	R. Atlas
5:00pm	Adjourn for the Day, Dinner	

November 7, 2008
Room 3H46

9:00am	Overview of the Day	R. Atlas, C. Conley, logistics
9:15am	ESMD briefing on human exploration	Marguerite Broadwell, HQ
10:15am	break	
10:30 am	Lunar Exploration/OSEWG activities	Gordon Johnston, HQ
11:00 am	Update on Science Committee activities	David Carrier/C. Conley
11:30 am	Discussion	R. Atlas
12:15pm	lunch	
1:15pm	Mars program and recent reports	Michael Meyer, HQ
2:15pm	Discussion and Recommendations	R. Atlas
3:00pm	break	
3:15pm	Discussion and Recommendations (cont.)	R. Atlas
4:00pm	Adjourn	

Appendix B Subcommittee Membership

Ronald M. Atlas (Chair)

University of Louisville

Dr. Gregory B. Baecher
University of Maryland

Penny Boston
Department of Earth and Environmental
Science
New Mexico Tech

Nancy Ann Budden
Rapid Reaction Technology Office
Office of the Secretary of Defense

Michael H. Carr
U. S. Geological Survey

W. David Carrier, III
Lunar Geotechnical Institute

Colleen Cavanaugh
Biological Laboratories
Harvard University

Catharine Conley, Executive Secretary

Science Mission Directorate
NASA Headquarters

Peter Doran
Associate Professor, Earth and Environmental Sciences
University of Illinois at Chicago

Ruth Faden
Johns Hopkins Berman Institute of
Bioethics
School of Public Health
Johns Hopkins University

Robert Lindberg
President and Executive Director
National Institute of Aerospace

Jere Lipps
Professor and Curator
Department of Integrative Biology & Museum of Paleontology
University of California at Berkeley

Gary Lofgren
Lunar Curator and Planetary Geoscientist
KT, Astromaterials Acquisition & Curation
Johnson Space Center/NASA

Claudia Mickelson
BSP Deputy Director, Office of Environment, Health & Safety
MIT

Harry Y. McSween, Jr.
University of Tennessee

Jon D. Miller
Michigan State University

Carlé M. Pieters
Department of Geological Sciences
Brown University

Susana Priest
University of Nevada, Las Vegas

Glenn Reynolds
Collage of Law
University of Tennessee

Andrew Steele
Geophysical Laboratory
Carnegie Institution of Washington

Laurie Zoloth
Feinberg School of Medicine
Northwestern University

Agency Representatives:
Penelope Firth
Environmental Biology
National Science Foundation

Richard Orr
International Policy and
Prevention
National Invasive Species Council
DOI - OS - SIO

Mary Voytek
U.S. Geological Survey
U.S. Department of the Interior

Victoria Hipkin
Planetary Exploration
Canadian Space Agency

Gerhard H. Schwehm
Solar System Science Operations Division
ESAC

Michel Viso
CNES/DSP/EU

Subcommittee Administrative Support:

Marian R. Norris
Science Mission Directorate
NASA Headquarters

Appendix C Attendees

Subcommittee Members

Ron Atlas, U of L, PPS Chairman
Penny Boston, New Mexico Tech
Nancy Ann Budden, OSD
W. David Carrier III, LGI
Cassie Conley, NASA HQ, PPO
Peter Doran, University of Chicago
Ruth Faden, JHU
Penny Firth, NSF
Victoria Hipkin, CSA
Robert Lindberg, National Institute of Aerospace
Jere Lipps, UCB
Gary Lofgren, NASA-JSC
Claudia Mickelson, MIT
Jon Miller, Michigan State University
Carlé Pieters, Brown University
Gerhard Schwehm, ESA
Andrew Steele, Carnegie Institute Washington
Michel Y. Viso, CNES, HQ
Mary Voytek, USGS
Laurie Zoloth, Northwestern University

Other Attendees

Zach Adam, FAA-AST
Linda Billings, NASA-GSFC
Denis Bogan, NASA HQ
Rebecca Gibbins, OGC
Gordon Johnston, NASA HQ
Gerhard Kminek, ESA
Marian Norris, NASA HQ
Jane Parham, NASA HQ, ESMD
Margaret Race, SETI Institute
John D. Rummel, ECU
Perry Stabekis, Windermere
Mindy Wilkinson, NISC
Gregory Williams, NASA HQ
Joan Zimmermann, Harris Corp

Appendix D
List of Presentations

1. Planetary Science Division Update [Kremic]
2. Ethics Briefing for Special Government Employees [Gilchrist]
3. Planetary Protection Results from COSPAR/Montreal 2008 [Rummel]
4. Lunar Exploration and OSEWG Activities [Johnston]
5. Exploration Update (Lunar) [Broadwell]
6. Essential Planetary Protection Policy/Commercial Concerns [Conley]
7. Mars Exploration Program [Meyers]