# NASA ADVISORY COUNCIL

# Planetary Protection Subcommittee

April 29-30, 2013

NASA Headquarters
Washington, D.C.

## MEETING MINUTES

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Eugene Levy, Chair

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Gale Allen, Executive Secretary

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***Zantech IT***

April 29, 2013

Welcome and Introduction
Incoming Executive Secretary of the Planetary Science Subcommittee (PPS), Dr. Gale Allen, welcomed members to the meeting and made some logistical announcements.

Words from the Chair
Dr. Eugene Levy, Chair of the PPS, welcomed members and noted that Dr. Robert Lindberg has taken on the responsibility of Deputy Chair for the PPS. He then reviewed recent findings and recommendations, which included a strong recommendation to NASA to adopt a procedural requirements (NPR) document enumerating planetary protection (PP) requirements for human extraterrestrial missions; this recommendation was accepted by NASA and is in work. Similarly, the PPS recommended the preparation of a Lessons Learned document for PP based on the experience of the Mars Science Laboratory (MSL: Curiosity), to be retained within the cultural memory of the agency. This effort is under also way. The PPS recommendation to extend a letter of agreement (LOA) between NASA and the European Space Agency (ESA) on cooperation in advancing PP technology has been accepted and is in work as well.

Three ongoing issues for the consideration of PPS are the health and vigor of technology development activities for PP; a related concern about the resources available to the Planetary Protection Officer (PPO) to fund studies for research and development (R&D) projects in PP; and an ongoing concern about the level of staffing in the PPO. While PPS believes that Dr. Cassie Conley is doing a heroic job in keeping the program going, one must also bear in mind the budgetary stresses of the day. Dr. Levy noted that 1 May marks the potential end of face-to-face meetings of the federal Advisory Committees for NASA. He reported that his most recent experience with a virtual meeting involving the NASA Advisory Council (NAC) Science Committee was wholly unsatisfactory. Dr. Allen noted that the Agency would be looking at this issue more closely after the budget rollout.

Planetary Protection at NASA: Issues and Status
Dr. Conley, PPO, presented an overview of activities in support of NASA's science goals. In addition to NASA Policy Document (NPD) 8020.7, embodying planetary protection policy, and NASA Procedural Requirements (NPR) 8020.12 on robotic exploration, a new NPR for human missions has been drafted and is in the process of revision. Dr. Conley noted that the purpose of the PPS is to provide advice on policy, programmatic direction, and technology, from the perspective of its deliberately broad base of expertise.

The framework of planetary protection within NASA involves intersections between science, technology, implementation, and policy. Policy elaboration involves coordination with the Office of International and Interagency Relations (OIIR), the Office of Legislative Affairs (LS), and the Office of General Counsel (OGC). Technology development involves coordination with the Offices of the Chief Engineer (OCE), Chief Scientist (OCS) and Chief Technologist (OCT). Improvements in implementation approaches, particularly for human missions, will require involvement of the Office of the Chief Health and Medical Officer (OCHMO) and the Office of Mission and Safety Assurance (OSMA). Overall planetary protection policy is implemented through the Science Mission Directorate (SMD) due to the underlying function of supporting scientific investigations, with involvement of the Human Exploration and Operations Mission Directorate (HEOMD) and the new Space Technology Mission Directorate when appropriate. PP must also take into account public opinion and taxpayer concerns. NASA also coordinates with international space agencies through letters of agreement, and through representation at bodies such as the Committee on Space Research (COSPAR), and through the State Department and Office of Science and Technology Policy (OSTP). Planetary protection technology development may also benefit from consultation with the Centers for Disease Control, the US Department of Agriculture and Department of Homeland Security; science through the National Science Foundation, National Institutes of Health and the Department of Energy. Effective regulation of mission activities would benefit from cooperation with the Federal Aviation Agency and Department of Commerce.

Dr. Conley reviewed the status of recent recommendations from PPS, including the decision to renew an LOA with ESA and to continue meeting with the European Space Agency every two years, noting travel constraints that must be overcome. A recommendation to evaluate the circum-Mars environment (Phobos/Deimos) is in work and will be addressed at the next ESA Planetary Protection Working Group (PPWG) meeting. PPS observations include a concurrence with the Japanese space agency's (JAXA) proposed classification of the Hayabusa-2 mission as a PP category V, unrestricted Earth return; a formal memo has been completed. At the November 2012 meeting of PPS, no formal recommendations were issued, but an observation of concern was documented, directed at the MSL Lessons Learned study.

A study performed by the European Science Foundation (ESF)-European Space Sciences Committee (ESSC), with participation of the US Space Studies Board, entitled "Mars Sample Return (MSR) Backward Contamination- Strategic Advice and Requirements" was released in July 2012. The report contains recommendations to be incorporated into current planning for MSR. It is anticipated that the study will be brought to the COSPAR Assembly in 2014.

An increasing number of targets (Mars, Europa) will require PP considerations for mission design. The PPO does not have funds for effective technology development for these future missions, an increasing programmatic concern. The cooperation between NASA's robotic and human space flight efforts will also require additional effort to ensure adequate oversight and consultation on PP. The increasing space exploration interests of private/commercial organizations has also raised concern with respect to the ground rules surrounding international cooperation, commercial exploration, and historical and environmental protection. Ms. Joanne Gabrynowicz, J.D. asked if there were any movement regarding a requirement to FAA to consider PP interests in the licensing process. Dr. Conley responded that Space Operations has asked for advice several times, and that this avenue of communication appears to be working well. NASA has a mechanism for providing input to FAA on launch certifications, and the PPS does have an ex-officio FAA representative.

Current missions within the scope of PP include the Dawn spacecraft that is *en route* to asteroid Ceres; this mission still needs to consult with the PPO regarding evaluation of the potential for water to be present at Ceres, and appropriate operational responses. Facilities support is still being established for the future InSight mission at Mars. Support is still needed for planetary protection technology development for the Europa Clipper mission. A sample-handling Centennial Challenge competition is in development, which would benefit the OSIRIS-Rex asteroid sample return mission as well as future efforts towards Mars Sample Return. Planetary protection requirements are still being refined for MSR; this effort has been ongoing since 2007. NASA is updating a Draft Test Protocol with ESA, as a continuation of update activities critical to ensuring timely support of future mission needs. In the Planetary Protection Research element of ROSES, there are usually $300-500K per year to support new starts in research, however in FY13 funding for new starts is not currently available. The PP budget has remained essentially flat since 2008, while programmatic activities since 2010 have increased. Dr. Lindberg asked if there were a document or resource on the funded ROSES projects, and drafts of selectable proposals. Dr. Conley agreed to put together a copy. Planetary Science Division (PSD) Director Dr. Jim Green also addressed this question, explaining that PSD was also working with PP on relevant instruments- "selectable" is a term that PSD uses to define award-worthy proposals under the conditions of a Continuing Resolution. "Selectable" means that a PI can receive funds when funds become available. Sometimes PSD can free up money by end of the fiscal year for these proposals; however information on selectables is proprietary until they are funded.

Planetary Science Division Status

Dr. James Green presented a budget update and a status of the division. The FY13 budget has been passed. The total NASA and total Science budget lines are $17.8B and $5.1B, respectively. Cuts and sequestration have moved NASA to identify high-priority activities, the Space Launch System (SLS), Multipurpose Crew Vehicle, International Space Station, Commercial Crew, and the James Webb Space Telescope (JWST), which must stay on budget, with implications for distribution for the rest of the program. Taking into account all requisite reductions, the true NASA and Science budgets are $16.6B and $4.8B, respectively. The Agency is completing the analysis of the full impact, and these impacts will be addressed in the Operating Plan, to be submitted to Congress on 10 May. The planetary budget was set at $1.415B, with Planetary research set at $192M, the Discovery program at $244M, and Mars at $450.8M. In the Operating Plan, $75M was allocated for Jupiter/Europa pre-formulation studies. The FY14 budget is $1.22B and at $1.252 in 2018. PSD did fairly well in that it filled in the FY13 "bathtub" with the FY14 budget. The FY14 budget includes $50M for the DOE Pu-238 restart (separate from NASA's radioisotope generator program), as well as funding for the asteroid retrieval mission (ARM). The $50M in the FY14 budget is for support of the infrastructure at DOE for the plutonium restart. Dr. Green acknowledged that this budget allocation will have an impact, and that he would be attempting to reduce its effects on the Research and Analysis (R&A) program, among others.

Funding in FY13/14 will support the continuing development of the lunar dust mission, LADEE; the Mars aeronomy mission, Maven; the OSIRIS-Rex asteroid sample return mission; and InSight at Mars. PSD will continue to operate science missions but with a reduced budget for extended missions as identified via a Senior Review. The Advanced Stirling Radioisotope Generator (ASRG) program will complete two flight units that will be stored for later flight opportunities. The primary missions of Curiosity and the remaining Mars Exploration Rover (MER) Opportunity are fully funded. Opportunity is on an extended mission that will continue to be funded. Lunar Quest has been phased out; its last mission is LADEE, and will be carried out as planned. The LASER program and Lunar Science Institute are migrating into the Planetary research line. The Lunar Reconnaissance Orbiter (LRO) will be transferred into the Discovery line. PSD will continue to support current R&A awards.

Budget changes include the decision to move forward with a Mars 2020 mission; NASA participation on an organics detection instrument (MOMA) for ESA's Mars 2018 mission; providing Electra communications package to ESA's ExoMars orbiter; and support of the InSight mission in phase B. PSD is selecting US principal investigators (PIs) for ESA's JUICE mission to Jupiter's icy moons, and is supporting balloon observations of the comet ISON in October 2014. PSD will also compete instrument studies and continue investment of $15M for the Europa clipper concept. Near-Earth Object (NEO) survey and characterization activities will be stepped up.

PSD accomplishments include the safe landing of Curiosity in Gale Crater and its discovery that Mars once had a habitable environment. GRAIL has completed its primary lunar gravity-mapping mission and is in an extended mission. Its recent major discovery is the detection of evidence of volcanic activity on the Moon. Dawn has mapped asteroid Vesta's gravitational field. The MESSENGER spacecraft has captured evidence of volatiles on Mercury; Astrobiology research has discovered novel microbes in a subglacial lake in Antarctica; and the Cassini extended mission has captured seasonal (based on Saturn's

30-year cycle) changes on Titan, as well as evidence of methane rain in that satellite's southern hemisphere.

The Administration has announced an asteroid redirect mission (ARM) concept, which aims to capture a 7-meter asteroid, nudge it to trans-lunar space, where it will be visited by astronauts in a lunar retrograde orbit. An important thing to note for this proposed mission is that the same sort of solar electric propulsion used to propel Dawn will be evolved to higher wattages (40kW) for this mission. LADEE will be launched on a Minotaur V rocket in August 2013. LADEE is designed to measure the lofted lunar dust and exosphere, and will carry an ultraviolet spectrometer and dust detector; it will also be able to test laser communication for moving high-volume data to Earth. LADEE's communications will have implications for future Mars communication, to provide much better data rates. OSIRIS-Rex, a $1B New Frontiers mission, is undergoing its final review in SMD today and will undergo an Agency review next month. The mission will launch in 2016 and travel to asteroid RQ36 1999 to return a sample. In PP terms this is an unrestricted return. OSIRIS-Rex will acquire 60 g of asteroid regolith and will also measure the Yarkovsky effect, and will utilize Stardust heritage for return to Earth. NASA will also be participating in JUICE, ESA's mission to explore potentially habitable icy bodies, Ganymede and Callisto, in the Jupiter system and has selected a UV spectrometer for this purpose.

FY13 funding will continue for the Europa clipper study, and will support a NASA Research Announcement (NRA) for instrument concepts for Europa; there will be 10-15 selections with a targeted budget of $750K to $1M for a one-year grant. ESA's Rosetta spacecraft is approaching comet CG; NASA has 3 PI instruments and many co-Is on this mission. NASA is planning balloon observations for comet ISON's closest Earth approach on 2 January 2014. The Solar System Exploration Research Virtual Institute anticipates selecting 7 teams at a level of $1.0-1.5M/year for 5 years, based on a new cooperative agreement. DOE has irradiated a Np-237 target, the analysis of which indicates that Pu-238 can be produced reliably in this manner. Plans and procedures are currently in progress to support DOE's production of 1.5-2 kg Pu-238 per year. A project baseline and confirmation for this DOE venture will be completed by December 2013.

The Curiosity rover is now making observations in a dry riverbed, drilling into rock, and has acquired material that shows the presence of phyllosilicates (clays). The mission is also seeing low deuterium-to-hydrogen ratios, consistent with water. Argon-36/38 measurements indicate Mars may have lost 85-95% of its atmosphere over its history. An ancient habitable environment exists at Yellowknife Bay; key elements are present, as well minerals in various states. Curiosity's ultimate goal is to reach Mt. Sharp by the end of its two-year mission. Mars is behind the sun (in conjunction) at this time, disrupting communication with the rover until 1 May. The rover has driven 730 meters, and is ready to go again; its instruments have checked out. Curiosity is close to halfway through its mission as Mars enters its summer season.

A Mars aeronomy mission, MAVEN, will determine the characteristics of the upper atmosphere and how it interacts with solar wind. Its launch is scheduled for November/December 2013. InSight, a Discovery mission to Mars, is in phase B. InSight will sit on the Mars surface to make seismic and heat flow measurements. A Science Definition Team (SDT) has been put in place for a Mars 2020 rover that will perform *in situ* science, and demonstrate significant technical progress toward Mars Sample Return

(MSR). Mars 2020 will utilize Curiosity's SkyCrane Entry, Descent and Landing (EDL) system; the total cost of its instruments is limited to $100M. The SDT final report is due in July, and an Announcement of Opportunity (AO) for Mars 2020 instruments will be released in early Fall. The mission lifetime is designed to be one Mars year.

Dr. Vic Teplitz commented that the Decadal Survey has recommended that if the Mars 2020 mission cannot obtain a sample, NASA should go to Europa instead. Dr. Green responded that the Mars 2020 SDT has the charge to develop a mission under strict budgetary constraints; it must use the Curiosity frame and is therefore subject to mass limitations. It remains to be seen whether a sample can really be acquired, analyzed, and cached with this rover. NASA is eagerly awaiting this input and will act according to Decadal Survey recommendations. Dr. Gerhard Kminek asked whether a cache would come from the instrument budget. Dr. Green noted that PSD has an overall budget for international participation in building instruments and spacecraft subsystems; ESA may have the opportunity to build the cache. The International Mars Exploration Working Group (iMEWG) meeting is targeted for late June, of this year by which time PSD will have some details from the SDT, and a discussion can begin.

Discussion

Dr. Lindberg raised the challenge associated with not having a regulatory body in the government to interact with commercial/private exploration; NASA cannot be a regulatory body for this activity. To Dr. Conley's knowledge, the question of such regulation had not been posed to OSTP. Ms. Gabrynowicz, J.D. commented that one way to do this is via Congressional action, or via interagency coordination, the latter of which would be created by the agencies themselves. There is a law on the books that states that space advertising from private agencies should not be intrusive. A launch license can be denied if appropriate qualifications are not met, according to this law. Perhaps the launch license could be used as a gateway for other activities. Dr. Levy noted that if PPS were to move on this issue, it is not transparently clear how to do so. International ties, and an effort to place an OSTP representative on the PPS, were two avenues seen as a reasonable way to address regulation. Dr. Allen reported having already put in a request for an OSTP representative.

Overview of Planetary Protection for Mars Sample Return

Dr. Conley presented a background on current concepts for MSR. A three-campaign architecture has been envisioned: the first mission collects samples, the second mission launches a fetch rover which then launches samples to Mars orbit, after which it is returned to a sample receiving-facility on Earth, etc. The Draft Test Protocol has concluded that it is philosophically possible to achieve this three-campaign architecture. Lisa May, Lead Program Executive for Mars Program, interjected that a potential architecture for sample return includes an Earth re-entry vehicle that is placed inside an orbiter, which is meant to break the chain of contact in Mars orbit (the transfer of sample material would occur at this point). The vehicle that enters Earth is contained. The opening of the entry vehicle would happen inside the Earth-receiving facility. The potential for sterilizing the outside of capsule on the return trip has been considered. At the level of the entire MSR campaign, there are PP requirements for all flight elements that have been in contact with Mars; these are category-V, restricted Earth-return elements. Landed elements are rated as category IVb. Numerous studies recommend that samples returned from Mars should be contained and treated as potentially hazardous until demonstrated otherwise. No uncontained martian material, including any parts of the spacecraft exposed to the martian environment, should be returned to

Earth unless sterilized. Hazards must be either destroyed or contained. Any sample return mission must have sufficient confidence on containment, approved protocols for containment and testing, and identification of the technical requirements flow that from the hazard assessment.

One scenario envisioned includes the landing of entry vehicles on Earth, rapid sample retrieval and containment, return to a dedicated facility, preliminary examination and characterization, examination for extant/extinct life, hazard testing, sub-sampling, and documentation. COSPAR guidelines hold that the outbound leg of the mission shall meet category IVb requirements; the mission and spacecraft must break chain of contact with Mars; reviews and approval for continuation of the mission (back to Earth) must be carried out; and unsterilized samples must be analyzed for life detection or biohazard testing.

Requirements for Mars Sample Return have evolved from previous guidance on the basis of the recent ESF-SSB study, which recommended that the probability of release of a single unsterilized particle of 10 nm or less should be less than $10^{-6}$. The size limit is based on the known dimensions of small microbes, viruses and gene-transfer agents (10-50 nm). The probability limit was selected as a level of risk consistent with other societally accepted ones. These limits are being used to guide ESA technical studies for a possible containment system for MSR. Dr. Jere Lipps commented that if these are reproducing organisms, one in a million could rapidly become much more than that. Dr. Conley agreed that this is exactly the problem for containment that deserves more thought. Dr. Lindberg suggested that engineering processes be used to demonstrate a realistic risk of releasing a particle of less than 10 nm. PPS members discussed the ramifications of heat and radiation sterilization, its implications for detecting extant life in a sample, and levels of acceptable risk associated with sample release. At the level of the entire campaign, any mission must be built around risk-based design, and recognition of common cause and single-mode failures, which will drive the redundancy and diversity of system design. ESA has been investing in technologies for verification of containment for a number of years. Any sample must be protected and contained at the same time. Dr. Mickelson noted that a Biohazard Level 4 facility meets these requirements, in general, but can only contain particles of 0.3 microns (300 nm) in size. Dr. Kminek reported that iMars discussions included these issues, as well as the consideration of having a dedicated facility. The current thinking is that the only way to release a sample from containment in an existing facility would be to inactivate it. Dr. Mickelson added that protecting the sample would require keeping it at Mars pressures; there are some conflicting considerations here. The space environment (heat and radiation) will change the sample too.

Dr. Kminek observed that MSR considerations are not starting from scratch; there are some Lessons Learned from the Apollo program and from Hayabusa that can apply to MSR. Dr. Teplitz asked whether planetary protection guidelines would be eventually published by COSPAR or accepted by international agencies. Dr. Conley responded that space agencies have agreed to follow COSPAR policy requirements for PP, in addition to following the framework of Article IX of the Space Treaty. This is a joint peer pressure activity, not legally binding, but very persuasive.

The subcommittee discussed and reviewed other campaign-level requirements according to category V, while recognizing that current Level 1 requirements for PP are bound to evolve and change over the next decade in response to new scientific information and capabilities.

Organic Contamination Control and ExoMars

Dr. Gerhard Kminek presented an overview of ESA's ongoing studies in contamination control, which confirm that the Viking approach for contamination control is more challenging than current methods for bioburden screening and still valid today. The Viking regimen requires that soil samples to be delivered to a gas chromatograph/mass spectrometer (GCMS) are each to contain less than one part-per-million organic material of terrestrial origin. As a consequence the sample path hardware must be cleaned to one nanogram per square centimeter; downstream hermetically sealed devices are implemented where possible, and a hot helium gas purge is utilized prior to sealing and pressurization. Viking cleaning protocols for contamination control are complex and time-consuming, but still viable today.

A current goal of the Mars Exploration Program (MEP) is to achieve an understanding of whether life ever existed on that planet. Dr. Kminek recommended that PPS consider the conclusions gleaned from a report produced by MEPAG's Organic Contamination Science Steering Group (OCSSG; 2003/4), which produced a well-populated table describing the amounts and types of contaminants (e.g., benzene, total reduced carbon, DNA) that were permissible for delivery to a GCMS (more specifically for SAM). One extra consideration described in this report is the use of flight blanks, and another is developing a breakdown of the contamination levels. For the ExoMars mission, an ESA science tiger team has concluded that it is acceptable to have an organic contamination in the 50-ng range for organics from biological samples, and up to a microgram for known and tested engineering sources. The team identified 22 critical materials based on a Declared Material List of subcontractors and instrument providers, selection of materials for testing and test specification, identification of a modeling approach for contamination transport analysis, and identification of a precision cleaning approach. The team also studied alternative/replacement materials determined through the use of extensive bake-out testing. Material control was based on elimination, conditioning, isolation (encapsulation) or characterization. Replacement materials, such as metals for seals, were also considered. The design path also studied protecting sensitive surfaces through segregation (sealed sample path) and overpressure, both of which are challenging to test. Cleaning is based on a sequence of solvent cleaning (sonication), bake-out, CO2 snow cleaning, and hot gas purge. Cleaning starts at the lowest (parts) level possible, and sterilization is performed at the highest integration level possible. Sealing the sample can eliminate problems associated with outgassing of organic materials used elsewhere in the path. Another way to deal with these issues is to take an organic inventory, and to understand the contamination transport path. There is also a time limit on how long the sample is exposed for analysis, so the use of positive pressure is recommended whenever possible.

In conclusion, the Viking experience is quite applicable to MSR, as the missions share similar intentions. Each discipline should evaluate, early in development, the specific requirements for MSR. Stringent contamination control requirements will have an impact on the flight system design, on the use of materials and components, model philosophy, and qualification and verification approach; this will be more difficult than bioburden control. Dr. Kminek recommended for further consultation the Bionetics Viking Report; MEPAG Science Priorities Related to the Organic Contamination of Mars Landers; and the Joint Science Working Group (JSWG) recommendations for technology development in contamination control.

Refinement of IVb Restricted Earth Return Requirements for MSR

Dr. Conley presented an overview of planetary protection measures for MSR. The Category IVb requirements currently state that the total bioburden of the spacecraft surface shall be less than or equal to 30 bacterial spores. Life detection on Mars will be analyzed by state-of-the-art technologies available at the time of the mission (which, as noted previously, will have to be estimated well ahead of time). Mission designers must have confidence in the conclusion of any protocol used for life detection; and the type of measurements and detection sensitivity will drive contamination limits of all elements of an MSR campaign, including initial sample caching missions. All of these processes are relevant to science and PP; the major difference is what each discipline does with the information. The Draft Test Protocol is being updated to reflect needs for MSR; one recently identification is the need to send blanks on the MSR campaign. A new framework for considering of life detection in returned Mars samples is to test the null hypothesis; i.e. there is no life in the samples. For PP, the null hypothesis would be that there *is* Mars life in the sample. A decision analysis strategy based on Bayesian statistics could be used to direct sequences of investigations to increase confidence in these conclusions. The definition of life is based on the evidence of order, replication, growth and development, energy utilization, response to the environment, and evolutionary adaptation: all of these characteristics are necessary but none are sufficient on their own. ESA is performing studies on a sub-sampling approach to address this issue. Initial characterization studies might include computed tomography, elemental imaging, and mineralogical analysis. Dr. Kminek added that ESA studies are addressing the confidence levels of sample processing. Dr. Levy commented that how much is promised with the sample must be carefully addressed through public policy.

Sub-sampling, prepared surface imaging, and microscale probes are other techniques being addressed. Defining requirements today for tomorrow's analyses are based on assumptions that the instrumentation to be used on Mars will be at least as sensitive as today's instrumentation, in that detection of organic material in bulk samples can attain parts-per-billion sensitivity, and that detection of organics on surfaces can attain femtomolar to attomolar sensitivity; further refinement of requirements based on these detection capabilities will be necessary. Dr. Lipps asked if sufficient time were allotted to update protocols between missions. Dr. Meyer explained that the Mars architecture was developed to allow reactions to discoveries, giving at least 6 years for protocol revisions. It has also been argued that it may well be 20 years before a sample can be retrieved. Dr. Kminek commented that in his experience, relevant flight systems generally remain unchanged over 10 years. In addition, whatever analysis is used in future missions will have to be well characterized, and one must have confidence in the data, implying that a sample return mission would probably not use the most recently introduced technology. Dr. Levy noted that the organics control may be the biggest challenge. Dr. Lindberg observed that while pace of instrument development may remain relatively modest, computational/data processing capabilities could be significantly more advanced. The Mars 2020 will require methods to characterize limits of contamination for sample, and a better refinement for measurements of life *in situ*, or for analysis of samples returned to Earth. There is currently no funding to develop caching techniques within PPO. The PPS considered a finding or recommendation calling for a committee to oversee sample return. Dr. Meyer noted that because the MEP is anticipating that a cache would levy requirements on future Mars missions, it has been discussing how to establish a body, such as a Board of Directors, on how to cache a sample for later retrieval- this might fit in well with PP requirements. Dr. Kminek, commenting on how the recent ESA/NASA/COSPAR workshop changed the concept of how to deal with samples returned from Mars - instead of having the science and planetary protection elements separate, where planetary protection gets part of a sample for biohazard assessment and the rest of the sample is for science, the new approach would have samples that are investigated by scientific methods and the data/information from the investigations are used by planetary protection and by science. . Dr. Doran observed that there seems to be a conflict between the goals of life detection and caching- are we hoping to find life or not?

<u>MSL LL study</u>

Mr. Mark Saunders presented a briefing on the progress of a Lessons Learned study on the Mars Science Lander mission, which includes PP aspects of the mission. Mr. Saunders, study leader, retired from NASA in 2008, and served in many capacities, most recently in the IPAO. The overall purpose of the study is to understand the technical and programmatic challenges of MSL and why deviations in the requirements occurred including PP. The study is expected to provide lessons learned and develop processes for future missions.. The goal is to approve these processes across the Agency for all future missions. The team is looking at NPRs and NPDs at Headquarters and centers, day-to-day internal processes, review processes, and decision processes at all levels, as well as suppliers. Team members are Noel Hinners, Sarah Gavit, Scott Hubbard, Jeff Leising, David Tisdale, Dolly Perkins, Bill Luck, Charles Fletcher, and Joan Zimmermann. Sarah Gavit and David Tisdale are the two team members who have a particular focus on PP.

Numerous questions are being addressed with regard to planetary protection. These include how categorizations were defined: were they clear, and were they implemented and managed properly? How were PP requirements verified? How well are the communication chains working for PP? The team has conducted roughly 40 interviews to date with all the major participants in MSL and PP, and has been reviewing documentation. During the next few months, the team will analyze data and draw conclusions, draft recommendations, prepare a final report and present results. Mr. Saunders offered to brief PPS with the study conclusions. The study will be completed by August and reported out in September. Mr. Saunders noted that radioisotopic power system (RPS) studies are not being covered in this effort.

Dr. Levy commented that there must be a continuing concern about the nature of the interaction between PP at Headquarters and the programs and projects; identifying the bureaucratic and personality impediments covers a lot of what needs to be covered. Dr. Lindberg agreed that the emphasis of the study appeared to be in the right place. Dr. Lipps remarked that imposition of any regime creates a resistance; PP ensures that life detection missions are assured, and it is hard to inculcate this philosophy into an entire work force. Dr. Levy noted that PP on the Viking missions cost quite a bit and hoped that institutional intelligence has improved since. Dr. Kminek commented that the most important factor in cost savings is to have all the requirements on the table at the beginning, and understand the implications- everything that comes late is costly and risky.

<u>Discussion</u>

PPS discussed various issues that had arisen from the day's proceedings. Dr. Levy suggested that members start thinking about getting PP incorporated early into the next phase of Mars exploration. Dr. Lindberg recommended discussing the question of whether policy should be revisited explicitly if evidence of extinct/extant life is found at Mars; should NASA write a trigger for evaluation in the policy itself? Mr. Perry Stabekis commented on this issue: studies at Stanford University have considered *a priori* knowledge of life extant- how do you base a design on a certainty of life existing? It depends on whether it is biohazardous; this will determine how sample analysis proceeds. Dr. Lindberg posed a question: if we thought we had extant life, do we decide that the sample will be examined only in Earth orbit? Dr. Conley stated that Agency policy is for such decisions to be informed by the best scientific advice based on the best current knowledge. Dr. Kminek described proceedings at COSPAR in which there is one panel that deals with policy, which subsequently is discussed by the entire Assembly. Any issue can be raised by members of the science community and the advisory groups. COSPAR has used this process for the Outer Planets, resulting in dedicated workshops, and modifications in the categorization of bodies in the Solar System. The process enables timely discussion of changes in knowledge and related changes in policy. Ms. Gabrynowicz, J.D. suggested that if a sample containing life were to be considered equivalent to a SETI signal, there are protocols written to deal with this situation. The basic principles rest on the presumption that the signal was sent to all humanity, which would dictate that the knowledge of the signal be widely disseminated. Dr. Conley noted that efforts are under way to bring an ethicist back on to the PPS.

<u>April 30, 2013</u>
Dr. Michael New, serving as Executive Secretary for the day, opened the meeting and made some logistical announcements.

<u>Annual Ethics Briefing</u>
Mr. James Reistrup delivered the requisite annual ethics briefing to the PPS.

<u>Discussion, re-cap of previous day</u>
Dr. Levy addressed new concepts for HEO, with a concern that planetary protection be brought to bear early in the development of such missions. Dr. Conley reported that she had been asked by HEO to provide input on instruments to be sent to Mars in advance of human exploration, to consider hazards that might be present in Mars materials, or whether human-associated microbes might be released at Mars, etc. Dr. Conley indicated that key participants require comprehensive training but pointed out that her invitation to participate marked a positive development.

<u>Planetary Protection for Human Exploration Missions</u>
Dr. Michael Wargo, Chief Exploration Scientist for HEOMD, presented a status of PP efforts in human exploration, and briefly described his background in the lunar science community, *in situ* resource utilization (ISRU), and radiation shielding. He reported having begun work on a task, recommended by PPS, to work with Dr. Conley on generating an NPR, numbered 8020.xx as a procedural requirements document that will incorporate guidelines from COSPAR to support planetary protection measures in human exploration endeavors. NASA has formed a core team to review and revise an existing draft NPR, and complete it over the course of the next calendar year. The core team members include representatives from PPO, OCS, OCHMO, OGC, and the four divisions of the HEO: Advanced Exploration Systems (technologies for beyond LEO, advanced EVA, habitation systems); Explorations Systems Development (launch systems, including Orion); Space Life and Physical Sciences Research and Applications; and the Strategic Analysis and Integration divisions (also tied to international efforts and robotics). Dr. Levy observed that SMD seems to be underrepresented in the team. Dr. Wargo responded that it was the responsibility of core team members to consult with the necessary expertise to vet particular subjects. Dr. Lindberg commented that planetary science and astrobiology were also not represented, and that perhaps

a PSD representative should be added as another core team member. Dr. Wargo took the comment under advisement.

The core team held a meeting in April to review its charter and discuss how to move forward. First comments on the draft are due on 3 May, and Dr. Conley is preparing a briefing to the core team on PP aspects. Dr. Conley provided the initial draft, and initial comments have been contributed by Dr. Wargo. The team is currently identifying the stakeholder base. Once identified, the draft will be distributed to stakeholders. The present goal is to submit the draft to the NASA Online Directive Information System (NODIS) at the beginning of this year's third quarter, and receive final approval by the end of the year. Dr. Wargo assured PPS that the relevant individuals would be included for review. Dr. Conley briefly reviewed the formal process carried out by NODIS. The final NPR will be signed by Bill Gerstenmaier and John Grunsfeld, Associate Administrators of HEOMD and SMD, respectively, as well as Administrator Bolden.

<u>Discussion</u>

Dr. Lindberg asked if NPRs are developed with any external input. Dr. Conley offered to send the 8020.xx draft to the PPS for commentary. Dr. Andrew Steele asked whether planetary protection was viewed favorably or unfavorably within the Agency. Dr. Conley gave the opinion that the perception over the past year or two, particularly with MSL, was that of heightened tension, and that an educational program would be very useful in dispelling this tension. If people understand the reasons behind planetary protection, they are much more supportive. Dr. Steele commented that once the feeling that PP is in the way happens, matters become complicated. There was general agreement that recognition of PP requirements up front, and education, would help ameliorate the problem. ESA does this better; every person on a project receives PP training. Ms. Gabrynowicz, J.D. raised the question of what policy would dictate if an astronaut becomes ill in orbit, and suggested that the revised NPR should have a sentence that should flag this issue. She cited maritime law, which once barred plague ships from entering ports; international space law is based on maritime law to some degree. Dr. Conley agreed that the problem needs to be addressed, and that inclusion in the NPR might be appropriate.

<u>Discussion: Findings and Recommendations</u>

The subcommittee discussed potential findings and recommendations. Dr. Levy raised two issues- one was the degree to which PP issues and the PPO are participating at the appropriate level in planning further Mars exploration and the MSR campaign. He felt that PP is insufficiently included in the design and development of these mission scenarios. Another issue is the question of whether NASA should promote or require PP training for all personnel in pertinent missions. Dr. Kminek noted that the ESA Planetary Protection Requirements document includes an applicable/normative reference document describing the bioburden control of cleanrooms. This applicable/normative document requires everyone working in a bioburden controlled environment to be trained, and applies to only those individuals who enter the environment. ESA and NASA hold joint agency-level training courses twice a year, which has been done for 10 years; the European training course is always oversubscribed. To function well, training must be described in the PP plan. In ESA, the project must establish a series of training opportunities at 4 levels (up to the projects to define the different levels and the scope), depending on the impact on the flight hardware, including the management (the most intensive training is at the technician level). For ExoMars, all the management has gone through the agency-level training, as well as lead system engineers. Having people on the other side of the table who understand the PP requirements is valuable. However, the training is time-consuming for those who must organize it. The ESA agency-level training is usually held at one location. Project-level training is usually held at subcontractor sites, allowing for some tailoring of subject matter. The conduct of the training flows down from the management office. So far, this approach seems to be effective for ESA missions. The ESA agency level training helps inform personnel as to why PP is necessary, what the implications are, and puts all requirements on the table from the beginning, which is a cost-saving measure. Training can be couched in terms of cost savings, safety, and risk management.

The subcommittee discussed the degree to which PP issues are being considered within the current planning for MSR. Dr. Steele recused himself from the Mars discussion due to his participation in the Mars 2020 SDT. Dr. Meyer commented that one of the reasons Dr. Steele is on the SDT is to represent PP. However, the SDT's job is to set goals and objectives for the mission, independently of NASA HQ. It was generally felt that PP should come into the purview at the pre-project phase, and that Dr. Conley should provide a briefing at that point. Mr. Stabekis commented that NPR 8020.12D contains a section addressing pre-project guidelines for planetary protection; the PPS might do well to endorse and strengthen these guidelines. Dr. Doran remarked that it sounds as if the ESA model is far more extensive in its educational practices for planetary protection. Dr. Conley mentioned the idea of providing on-line courses, given recently imposed travel restrictions at NASA. Dr. Lindberg quoted some 8020.12D text, observing that it seemed insufficient to engage a deeper discussion of how PP implementation is carried out. Dr. Conley agreed with this assessment, but stated that communication has improved. Dr. Lindberg led an effort to write a finding (seen in appendix E) on PPO involvement in the mission project phase.

The PPS briefly discussed future meetings; Dr. Levy undertook the writing of a letter to support the continuation of face-to-face meetings of the subcommittee, as interaction was deemed critical to the advisory effort.

<u>Europa Mission Concepts/Budget/Planning for Mars</u>

Dr. Curt Niebur, Outer Planet Flagship (OPF) Program Scientist, gave a presentation on the latest Europa Flagship mission concepts. Europa has been a high priority for NASA since 2007, and has been continuously studied. The most comprehensive concept developed to date was that of a Jupiter/Europa Orbiter (JEO), which had been given the same scientific priority as MSR by the planetary Decadal Survey. However it was considered disruptively expensive at $4.7B in 2015 dollars. Thus a move was made to produce a reduced-cost, lower-complexity mission to Europa. In addition, NASA has always assumed that a Europa mission would fly only in the event of an additional budget wedge for PSD. The primary science goal for the exploration of Europa is to investigate its habitability. Habitability themes include study of its water, chemistry, and energy. Objectives of a Europa mission are to explore the moon's ice shell and ocean, composition and geology.

After the Decadal Survey was released, NASA refocused the mission solely on Europa science, and carried out studies of three different concepts: a multiple flyby of Europa in Jupiter orbit, a Europa orbiter, and a Europa lander, representing a three-element breakdown of what had been proposed for JEO. Each mission was designed to be independent and stand-alone, and each with its own meritorious science. After this report was submitted in May 2012, it was thought that the lander would be too difficult to build and design (soft landing, body not well understood, no high-resolution photos of Europa). NASA then tasked the team to expand the science scope for the flyby and the orbiter while maintaining a cost cap of $2B (2015 dollars), excluding the cost of a launch vehicle. A flyby was focused on investigating the ocean, while the orbiter focused on investigating the ice shell, composition and geology science objectives. The study also considered reconnaissance for potential future Europa landers. Low data rate is seen to be a disadvantageous issue for the orbiter also provided insufficient results for composition. Eventually NASA settled on the concept of the Europa Clipper mission: 32 low-altitude, simple, repetitive fly-bys of Europa from Jupiter orbit over 2.3 years. The Clipper mission would provide a detailed study of globally distributed regions of Europa, simple repetitive science operations, and will carry a high-resolution camera and thermal imager. The base payload includes an IR spectrometer, topographic imager, and ice-penetrating radar. Elements were added to help capture the ocean objective: need a geophysics package containing a Langmuir probe, radio science, magnetometers, etc. Downlink has always been an issue; the radiation environment is not quite as severe in flyby as in orbit.

Baseline planetary protection measures include dry heat microbial reduction (DHMR) at the system level, but this plan is still under evaluation. The mission is considering the probability of impact on Europa over time, versus sterilization via the Jupiter radiation environment. NASA is also looking at the availability of components compatible with DHMR, and the future availability of sterilization facilities. A 2012 SSB study on PP recommendations for icy bodies is still under evaluation. Dr. Conley explained that a recent SSB workshop concluded that it would integrate some concepts within the decision tree for planetary protection, while adhering to the previously established probabilistic approach – this is what will be recommended to COSPAR. Dr. Conley recommended that the Europa study team not change its approach. Dr. Niebur agreed to await further refinements while continuing according to the present NPR. He added that a recent NRA for Europa instruments had been released, which explicitly called out PP challenges involved in the Europa Clipper mission.

<u>Discussion</u>

PPS considered draft findings. Referring to Dr. Steele’s earlier recusal, Dr. Levy remarked that blank wall separation between the SDT and PP does not advance interests and is deleterious. Dr. Lipps advocated a more forceful statement on planetary protection education and adherence. Dr. Steele related his experience at a workshop in February on planetary protection elements for MSR, observing that competent scientists will be needed for appropriate sample-handling. While there is a view that PP is an problem for the projects, one can bring an enhanced flow-down of science requirements into sample handling to meet PP requirements simultaneously.

<u>New Developments in Technology</u>

Dr. Prasun Desai, Director of Strategic Integration and Analysis in the Space Technology Mission Directorate (STMD), presented an introduction to the directorate. STMD was established to enable a new class of NASA missions, deliver innovative solutions to NASA and the Nation, benefit the economy, create markets, spur innovation, and train the next generation of scientists and engineers. Since 1980, studies have suggested that regular investment in new transformative space technologies is necessary. STMD will engage academia, industry and small businesses, in its activities. The mission directorate will address challenges for deep space exploration such as communication, navigation, environmental control and life support, radiation mitigation, propulsion, and EDL technologies, and new trends in space technology such as small spacecraft (cubesats and microsats). In 2013, STMD demonstrated the feasibility of an inflatable heat shield for larger payloads (IRVE-3 experiment launched out of Wallops), and fabricated a 2.4-meter cryogenic propellant tank in FY2012. MSL demonstrated an STMD instrument suite on its heat shield (MEDLI) to provide real-time atmospheric and heating data from embedded sensors during entry, descent and landing at Mars. Technologies from six Small Business Innovative Research (SBIR) companies played a role in the MSL/Curiosity mission as well.

The FY13 budget for STMD is $600M, and for FY14 $743M; the budget is flat through the outyears. This funding has been divided between the Office of the Chief Technologist (OCT) and STMD. The former "Edison" program has been segued into Small Spacecraft Technology Development. The FY14 strategy is to prioritize areas based on the Strategic Space Technology Investment Plan and the NRC report on NASA Space Technology Roadmaps; align support for the Asteroid Retrieval Mission (ARM) (high-powered Solar Electric Propulsion (SEP)); ensure progress on transformative and crosscutting technology projects; maintain a sustainable pipeline of revolutionary concepts and develop the workforce through a grants program; create new space markets; explore alternate technology approaches, and enhance technology transfer and commercial partnership opportunities.

The FY14 budget increase will support key space technology projects, accelerate SEP technology, and support Congressionally mandated increases in the SBIR and STTR programs. The FY14 budget will be distributed among the NASA centers, including Glenn Research Center (cryogenic propellant and storage transfer, and SEP).

Approximately 10% of STMD investments are in low TRL technologies, as recommended by the NRC Final Report on Space Technology Roadmaps and Priorities; approximately 69% is in core areas, and the remaining is invested in adjacent and complementary areas, also as recommended by the NRC. Core areas include launch and in-space propulsion; high-data-rate communications; lightweight space structures, environmental control and life support systems; space radiation; scientific instruments and sensors; EDL; and robotics and autonomous systems. If PP were to be involved in any of these areas, it would be relevant to plans for humans on a planetary body, perhaps for forward contamination concerns, but not in transit. STMD is not funding any PP projects at this time. Dr. Conley stated that topics relevant to PP would include as space suit design and scientific instruments; for example, open-loop cooling could not be used in a Mars environment. Dr. Lindberg noted that "breaking the chain of contact" at Mars could also be thought to fall under STMD proposals. The PPO does have input into the SBIR/STTR programs at JPL, to some extent. Dr. Desai reported that for MSR, SMD is also considering the chain of contact issue in its division. The STMD is more crosscutting, benefiting multiple customers. The responsibility for the SSTIP is with OCT. STMD has direct management and budget authority of the 8 programs at the centers, while OCT continues to serve as the Administrator's principal advisor and advocate on the Agency-wide technology policy and program. OCT documents and communicates the societal impacts of the Agency's technology efforts in various formats, such as the NASA Spinoff magazine. Dr. Steele remarked that the cross-cutting framework should be more coordinated within the Agency directorates. Dr. Desai responded that STMD is not developing technology for the sake of technology, and actively coordinates with the divisions, and other government agencies in efforts as diverse as system or concept studies, ground-based demonstrations, etc., depending on the partnership. Ms. Gabrynowicz, J.D. asked if there were a formal definition for "game changing" technology. Dr. Desai replied that for STMD purposes, the phrase refers to bridging the gap between low and high TRL technologies.

The Space Technology portfolio has nine subareas, all of which adhere to a stakeholder-based investment strategy, and invests in a comprehensive portfolio. The directorate is not looking for incremental improvements but at technologies that make strides, take an informed risk posture, and position NASA at the cutting edge of technology. Fourteen technical areas include nanotechnology, EDL, communication and navigation, ground and launch systems processing. For MSL, several SBIR companies, such as GrammaTech, StarSys, Creare, Yardney, and Honeybee Robotics, were involved in payload development. Similar investments are being made in SLS at present. Crosscutting Space Technology development enables revolutionary advances in broadly applicable technology for NASA's future science and exploration needs. Each mission directorate or division comes to the STMD with its needs. Some development in this budget line include supersonic decelerators, solar sails for the SunJammer project, a deep space atomic clock, Edison smallsat networks, and commercial access to suborbital space.

Exploration technology development in green propellants, batteries, fuel cells and space propulsion, life support and space resource utilization components is also taking place. Infusion of these technologies is being matched to various future missions in HEO.

In FY14, STMD will focus on the "Big Nine" projects, including deep space navigation, EDL, SEP, and composite cryogenic tanks. Major recent events include the incorporation of 3 cubesats on the recent Antares launch from Wallops Island, which demonstrated a low-cost cell phone communication scheme (PhoneSat). Asked if the supersonic decelerator project was aware of PP requirements for Mars, Dr. Desai took an action to look into the matter. STMD is also preparing for ARM; the directorate will focus on the SEP aspect, Hall thrusters, the design of xenon propellant tanks, and flight hardware procurements for the solar array. STMD has also been collaborating with the US Air Force, NOAA, the US Army, the Defense Advanced Research Projects Agency (DARPA) and the Veteran's Administration (VA), among others. The directorate is also addressing the next-generation aspect of space technology, with over 350 activities in 100 US academic institutions.

<u>HEOMD</u>

Mr. Jason Crusan, director of the Advanced Exploration Systems Division (AESD) in HEOMD, discussed the division's approach to steadily building, testing and refining technologies to enable missions of higher complexity further from Earth. The division uses design reference missions (DRMs) as bounding case analyses for mission classes. In response to a question, he reported that the directorate is incorporating some PP guidelines via some biological monitoring instruments. Along with the DRMs that provide specific destinations and identify strategic knowledge gaps (SKGs), HEOMD has asked the Lunar Exploration Analysis Group (LEAG), Small Bodies AG (SBAG), the Mars Exploration Program AG (MEPAG), as well as other relevant groups to provide feedback. Each of the AGs has published its assessment of the SKGs, some of which may involve planetary protection issues.

From the DRMs and key measurements, HEOMD has begun to develop common capability roadmaps tied to the technology roadmaps. The directorate also adheres to strategic principles: execute to the current budget with modest increases; apply high-TRL technologies for the near term; carry out near-term mission opportunities with a defined cadence; provide opportunities for US commercial business; develop a multiuse space infrastructure; and aim for significant international participation. Objectives are to look at system level integration, using a risk reduction program that is hardware-centric, with testing in real environments. There is also heavy emphasis on the civil servant workforce, which is highly integrated with STMD and working closely with SMD on robotic precursors. The AESD divides its work into key domain areas such as crew mobility, deep space habitation, and vehicle systems. Its budget is about $140M, about 60% of which is civil servant labor cost, at all ten centers.

Currently AESD is working on a portable life support system, the first new system for extravehicular activity (EVA) in 30 years. The new Z-1 suit is in the testing phase, with a habitable airlock made of composite materials, built in-house at Johnson Space Center. For deep-space habitation systems, work has begun on spacecraft fire safety experiments, the first of which will be a large-scale fire experiment on the Orbital Sciences ISS cargo vehicle Cygnus as it begins its terminal descent. A Critical Design Review (CDR) has been completed for radiation monitors that will fly on the EFT-1 mission in 2014. The radiation monitor sensors are descended from the RAD system on MSL. These sensors are much smaller. Five of these sensors are now on ISS and collecting data, and will be installed on Orion in the future.

For use in deep space habitations, a Multipurpose Logistics Module (MPLM) mockup is being refurbished for integration of crew accommodations, life support, power, and avionics; and an inflatable module is being developed for demonstration on ISS in 2015. In the vehicle systems domain, AESD is developing Morpheus, a test vehicle, and has recently completed helicopter flight tests of an integrated ALHAT system. The division is also looking at nuclear thermal propulsion, with fuel element testing under way (heating $H_2$ electrically). In the operations domain, work is progressing on a Ka-Band Objects Observation and Monitoring System, a next-generation system for near-Earth asteroid characterization. Three 12-m antenna dishes have been installed at Kennedy Space Center, and tanks have been installed to demonstrate a zero boil-off cryogenic propellant storage system, with autonomous control of propellant loading. In the operations domain, AESD is demonstrating the Disruption Tolerance Network, a next-generation networking protocol that is remotely controlling SPHERES free flyers on ISS. In the Robotic Precursor Activities domain, Goldstone obtained radar imagery of the 2012 DA14 asteroid as it passed Earth in February 2012. This domain is also monitoring the output of the RAD instrument on MSL.

Discussion

PPS returned to discussion and generation of findings. Dr. Lindberg offered as a final thought, given the parallels between PP and OSMA, a suggestion to engage with OSMA with an eye toward informal discussion as to how it cuts across the agency, and how it operates in line management. Dr. Conley took an action to arrange this. Dr. Levy adjourned the meeting at 4:30 pm.

# Appendix A
# Attendees

***Planetary Protection Subcommittee Members***
Eugene Levy, *Chair Planetary Protection Subcommittee*, Rice University
Catharine Conley, *Planetary Protection Officer*, NASA HQ
Peter Doran, University of Illinois, Chicago
Joanne Gabrynowicz, University of Mississippi
Gerhard Kminek, European Space Agency
Robert Lindberg, *Deputy Chair PPS*, University of Virginia
Jere Lipps, University of California, Berkeley
Jon Miller, University of Michigan
Claudia Mickelson, Massachusetts Institute of Technology
Vic Teplitz, Department of State, *ex officio*
Gale Allen, *PPS Executive Secretary,* NASA HQ

***NASA Attendees***
Barbara Adde, NASA HQ
Jason Crusan, NASA HQ HEOMD
Prasun Desai, NASA HQ STMD
Robin Frank, NASA GSFC
James Green, NASA HQ PSD
Lisa May, NASA HQ SMD
Michael Meyer, NASA HQ SMD
Marion Norris, NASA HQ
Michael New, NASA HQ SMD
Trent Perrotto, NASA HQ
J.A. Reistrup, NASA HQ
Dave Richardson, NASA HQ STMD
Mary Voytek, NASA HQ SMD
Michael Wargo, NASA HQ HEOMD

***Non-NASA Attendees***
Charles Fletcher, Dell/NASA OCE
Sarah Gavit, MSL Lessons Learned Study, JPL
Linda Karanian, Aerojet
Jim Lochner, USRA
John Malay, Lockheed Martin
Christy Rivira, NASA HQ
Mark Saunders, Self
Perry Stabekis, Gentex
Richard Warwick, Lockheed Martin
Joan Zimmermann, Zantech IT

# Appendix B
# NAC PPS Subcommittee Membership

**Eugene H. Levy (Chair)**
Provost/Professor of Physics and Astronomy
Rice University

Penny Boston
Department of Earth and Environmental Science
New Mexico Tech

Colleen Cavanaugh
Biological Laboratories
Harvard University

**Catharine Conley, Planetary Protection Officer**
Planetary Sciences Division
Science Mission Directorate
NASA Headquarters

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

**Gale Allen, Executive Secretary**
NASA Chief Scientist, acting
Office of the Chief Scientist
NASA Headquarters

Joanne Gabrynowicz, J. D.
Editor-in-Chief, Journal of Space Law
University of Mississippi School of Law

Robert Lindberg
University of Virginia

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

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

Jon D. Miller
Joseph A. Hannah Professor of Integrative Studies
Michigan State University

John D. Rummel
Director, Institute for Coastal Science and Policy
East Carolina University

Andrew Steele
Geophysical Laboratory
Carnegie Institution of Washington

**Agency Representatives:**
Dale Griffin
Environmental/Public Health Microbiologist
United States Geological Survey

Victoria Hipkin
Program Scientist, Planetary Exploration
Canadian Space Agency

Gerhard Kminek
Planetary Protection Officer
European Space Agency

Gerhard H. Schwehm, SCI-OS
Head of Solar System Science Operations Division
ESAC

Michel Viso
Astro/Exobiologie
Astrobiology
Vétérinaire/DVM
CNES/DSP/EU

**Subcommittee Administrative Support:**
Ms. Marian R. Norris
Management Support Specialist
Science Mission Directorate
NASA Headquarters

# Appendix C
# Presentations

1. Planetary Protection at NASA: Issues and Status, *Catharine Conley*
2. Planetary Science Division: Issues and Status, *James Green*
3. Overview of Planetary Protection for Mars Sample Return, *Catharine Conley*
4. Organic Contamination Control and ExoMars, *Gerhard Kminek*
5. Refinement of Category IVb Restricted Earth Return Requirements for Mars Sample Return, *Catharine Conley*
6. OCE Mars Science Lander Lessons Learned Study, *Mark Saunders*
7. HEO and Planetary Protection, *Mike Wargo*
8. Europa Mission Concepts, *Curt Niebur*
9. New Developments in Technology, STMD, *Prasun Desai*
10. New Developments in Technology, HEOMD, Jason Crusan

# Appendix D
# Planetary Protection Subcommittee Agenda

NASA Headquarters, Washington D.C. April 29-30, 2013

## April 29, 2013 (Room 9H40 (PRC))

| | | |
|---|---|---|
| 9:00 am | Welcome, Orientation, Introductions | Gale Allen and Marian Norris, HQ |
| 9:15 am | Words from the Chair | Eugene Levy, Rice Univ. |
| 9:45 am | Planetary Protection at NASA: Issues and Status | Cassie Conley, PPO/HQ |
| 10:15 am | Break | |
| 10:30 am | Planetary Science Division Update | Jim Green, PSD/HQ |
| | – Budget | |
| | – Planning for Mars | |
| 11:45 pm | Discussion | E. Levy/G. Allen |
| 12:00 pm | Lunch | |
| 1:00 pm | Overview of Planetary Protection for Mars Sample Return | C. Conley |
| 1:30 pm | Organic Contamination and ExoMars | Gerhard Kminek, ESA |
| 2:15 pm | Refinement of IVb Restricted Earth Return Requirements for MSR | C. Conley |
| 3:00 pm | Discussion | E. Levy/G. Allen |
| 3:30 pm | Break | |
| 3:45 pm | OCE Lessons Learned Study | Mark Saunders, Team Lead |
| 4:30 pm | Discussion | E. Levy/G. Allen |
| 5:00 pm | Adjourn for the Day | |

## April 30, 2013 (Room 8Q40)

| | | |
|---|---|---|
| 8:30 am | Annual Ethics Training | James Reistrup , HQ |
| 9:30 am | Overview of the Day | E. Levy/M. New |
| 9:40 am | HEO and Planetary Protection | C. Conley/Mike Wargo, HEO |
| 10:30 am | Break | |
| 10:45 am | Discussion and Recommendations 1; Next Meeting Dates | E. Levy/M. New |
| 12:00 pm | Lunch | |
| 1:00 pm | Europa Mission Concepts | C. Niebur |
| | – Budget | |
| | – Planning for Mars | |
| 2:00 pm | Break | |
| 2:15 pm | New Developments in Technology: | |
| | – Space Technology Mission Directorate | P. Desai |
| | – Human Exploration Mission Directorate | Jason Crusan |
| 4:00 pm | Discussion and Recommendations 2 | E. Levy/M. New |
| 4:30 pm | Recap and Adjourn | |

# Appendix E
# Recommendation

The Planetary Protection Subcommittee recommends that projects assure the participation of the Planetary Protection Officer (PPO)at the outset of project planning. Knowledge of planetary protection requirements and planetary protection implementation alternatives can be useful information for science definition activities. As noted in NPR 8020.12D, projects can benefit from communication with the PPO during preproject activities, to obtain preliminary mission categorization. PPO communication at the preproject phase can also inform the evaluation of preliminary mission design alternatives in the light of planetary protection requirements. Early involvement of PPO in the preproject phase has been shown to reduce cost over the course of the project by eliminating the need for costly remediation later in mission development.