

NASA ADVISORY COUNCIL

Planetary Protection Subcommittee

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MEETING MINUTES

Eugene Levy, Chair

Max Bernstein, Executive Secretary

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Welcome and Introduction

Dr. Max Bernstein, Executive Secretary of the Planetary Protection Subcommittee (PPS) opened the meeting with an administrative re-cap. Noting the long time interval since the previous PPS meeting, he briefly reviewed prior recommendations dating from November 2008. These recommendations included a designation of the Moon as a category 2 destination (done); protection of past activity on the Moon (the subject of an upcoming workshop); a series of recommendations on contamination (in process); a recommendation on the development of instruments, analog studies, and technology (in flux); a recommendation to establish PPS in a direct reporting relationship within the NASA Advisory Council (NAC) structure (not acted upon); a recommendation to place the Planetary Protection Officer (PPO) as a full-time position at NASA Headquarters (done); and a request to NAC for feedback on recommendations made by PPS (not acted upon). Bearing in mind that the NAC structure has changed, Dr. Bernstein welcomed the chance to review these recommendations under new conditions.

Dr. Eugene Levy, Chair of the PPS, welcomed members, and addressed the challenge of bringing PPS back into being as a regularly functioning body, in light of the changing nature of NASA's vision and future pathway. He regarded PPS as both a regulatory and science-promoting subcommittee, also bearing in mind the higher conceptual goal of protecting potential life in the universe.

Planetary Protection at NASA/Overview

Dr. Catharine (Cassie) Conley, PPO, reviewed the goals of planetary protection at NASA, which concern the prevention of both forward and backward contamination of bodies in the Solar System. As observers, scientists must also be mindful to avoid muddling potential evidence of extraterrestrial biota with contamination from Earth. Life detection on Earth itself is indeed problematic, as fewer than 0.1% of known microbes are culturable by laboratory methods. Planetary protection also extends to preserving Earth's integrity in the case of sample returns from other bodies. NASA has learned much from the Apollo program. It is now believed that the Moon is essentially sterile, but recent evidence suggests that Mars and Europa may harbor life of some sort. Legal requirements concerning sample return include regulations formulated by the National Environmental Policy and National Security Acts; NASA also currently follows a Draft Protocol in planning for the handling of returned martian samples. The Draft Protocol states that martian samples should be contained at a biohazard level greater than biosafety level (BSL)-4. The Outer Space Treaty of 1967 is also an essential influence on planetary protection policy, in particular Article IX. Ms. Joanne Gabrynowicz, newly appointed PPS member, noted that Article IX is an active subject in law at the present time.

The Committee on Space Research (COSPAR), representing an international consensus, maintains a planetary protection policy as well; the current policy in effect was approved by COSPAR in 2002 at the World Space Congress. NASA adheres to COSPAR, and maintains NPD document 8020.7G, which elucidates the particulars of the policy; this document has been refined over time as NASA responds to planned human and robotic exploration activities.

Dr. Conley reviewed the role of PPO. Among PPO duties are the obligation to assure that research on planetary protection technology is performed, to monitor spaceflight missions to ensure planetary protection requirements are met, and to certify that missions are compliant. The PPO also prescribes standards, certifies policy to the Science Mission Directorate (SMD) Associate Administrator (AA). NASA also uses advice and reporting from the Space Studies Board (SSB) in administering planetary protection policy and requirements. In 2005, with the reorganization of the NAC, the Planetary Protection Advisory Committee (PPAC) was reformulated as PPS, representing a broad range of disciplines and

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cross-disciplinary sciences in planetary protection. Between 2005 and 2008, an average of 4-5 recommendations per meeting were transmitted to the NAC Science Committee by PPS- none of these recommendations have been formally communicated back to PPS. In 2009, however, a detailed summary of these recommendations were provided to the newly reorganized NAC Science Committee.

Planetary protection philosophy focuses on a central presumption of ignorance, recognizing that life-supporting environments are exceedingly diverse in temperature, pH, pressure, and ionizing radiation environments, etc. Mission constraints therefore depend on mission and target objects/planets; these constraints include reduction of contamination on spacecraft, restrictions on handling of returned samples, documentation of spacecraft trajectories, and archiving. Guidelines separate missions into 5 categories, from little restriction, through documentation only, to restrictions on Earth-return that revolve around both forward and backward contamination. Preventing contamination of bodies based on calculations of probability that a particular number of organisms can survive cruise phase, impact, radiation, and other conditions of the space travel environment. Organisms are further subdivided into 4 types, from spores to radiation-resistant bacteria. In the New Frontiers program, the PPO has been active in formulating categories for the upcoming requirements for Europa, currently considered category III/IV. Precautions focus on avoiding contamination of Europa's observed "oceans." The Juno mission is also taking into account any probability of impacting Europa, thus the implementation phase will provide data on the reliability of the spacecraft, type of organisms on the spacecraft, and the probability of the space environment eliminating organisms in transit and during impact. Terminal sterilization is a basic approach to decontamination; it is expected that the Europa orbiter will probably have to utilize some form of terminal sterilization.

Categories for Mars missions are in the III/IV range. There are now numerical requirements for Mars. For example, an orbital lifetime requirement for Mars orbiters has been defined as 20 years after launch at greater than or equal to 99% probability, and 50 years after launch at a 95% probability. Special regions have also been defined on Mars; these are regions that are more likely to harbor life and are defined by the level of water activity (1/relative humidity) of 0.5 or greater, and a temp of -25°C or warmer. Special regions are suspected to occur mostly at the mid-latitudes of Mars. Dr. Conley noted that the spacecraft itself, if carrying a heat source such as a radioisotope thermal generator (RTG), can be designated a special region, or can transform a Mars site into a special region.

There is much ongoing activity in progress for Mars Sample Return (MSR), particularly in preventing backward contamination. Current issues in forward contamination control include measuring microbial diversity using DNA sequencing (DNA "barcode" database). A series of workshops have been held on the subject, and more are in planning to support the development of planetary protection systems that would support exploration at Mars.

Overview of Planetary Science Division (PSD)

Dr. James Green, Director of the Planetary Science Division (PSD), reviewed the current status of planetary science at NASA. He noted that a number of division staff have moved on, but that new civil servants and new detailees are arriving. PSD expects to have several civil service opportunities for Program Scientists at Headquarters this year. An advertisement for a Research and Analysis (R&A) lead has been released and closes May 17th.

PSD Budget

The FY10 budget currently stands at \$1.43B for PSD, and at \$1.45B in FY11. The division has already made plans to spend more on near-Earth object (NEO) detection activities; to extend the Cassini mission to observe seasonal change at Saturn/Titan; and to support future mission planning for Mars, New

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Frontiers, and the Discovery program. The Earth Sciences Division (ESD) has received a healthy augmentation to revitalize the Earth Sciences program in support of global and climate change research.

The new Planetary Decadal Survey is expected to be released in May 2011, and its output will potentially change program content to reflect newly prioritized missions. Recent accomplishments in science are the selection of three, \$1B-class, New Frontiers missions for phase A studies: MoonRise (Lunar South Pole/Aitken Basin sample return); OSIRIS-Rex (asteroid sample return); and SAGE (Venus lander). Discovery's Announcement of Opportunity (AO) schedule has been established and will be released in June 2010. PSD has also received proposals for instruments on the European Space Agency's (ESA) Mars Trace Gas Orbiter for the 2016 opportunity. PSD has also been focusing on the re-initiation of Pu-238 production in the U.S. Per Presidential direction, NASA and the Department of Energy (DOE) will share the cost of this effort. Sufficient plutonium will be necessary to fly the next NASA-only Outer Planets Flagship mission; at present, NASA is working with ESA to fly to the Jovian system in the case that this production cannot be realized. A detailed plan is in the signature process and is not yet public.

The FY11 PSD budget provides an additional \$20M/yr for NEO activities, in concert with a response to a recently released National Research Council (NRC) NEO Survey and Mitigation report. The objective of current PSD activities is to detect and track 90% of NEOs, and find those that measure at least 140m in size which have any potential to collide with Earth. NASA is planning to use this significant budget increase to respond to the NRC recommendations, including enhancing detection efforts in both space- and ground-based systems. Current systems for NEO detection include the LINEAR facility and the Catalina Sky Survey. PSD also plans to make use of the Air Force Pan-STARRS program. PSD has also been able to obtain data from the Astrophysics WISE (Wide-field Infrared Survey Explorer) mission, an infrared sky-mapping mission. WISE has already found several new comets and many NEOs and is continuing to collect data. The Minor Planet Center will also be updated to make initial NEO orbit determinations and serve as a discovery clearinghouse. Plans are also under way to enhance the Research Opportunities in Space and Earth Science (ROSES) solicitation to extend the database of small body data, which will enable collection of data through Pan-STARRS, as well as support for continued operation of the National Science Foundation (NSF) Arecibo and NASA Goldstone radar facilities to help determine parameters necessary to characterize potentially hazardous objects.

Missions

Operating planetary missions include MESSENGER, which has made its third encounter with Mercury in preparation for an orbit around the planet; ESA Venus Express; EPOXI and NExT (comet flybys), ESA Rosetta (comet rendezvous); and Hayabusa (due to land in June). The Dawn mission is its way to the asteroids Vesta and Ceres. Missions in planning include Juno (Jupiter), which is moving toward a 2011 launch, and NASA is also working with ESA on a Europa Jupiter System Mission (EJSM). The Cassini mission has been extended to 2017; New Horizons is on its way to Pluto and other objects in the Kuiper Belt. Lunar missions Chandrayaan (lunar mapping) and LCROSS (lunar impactor) are complete. The Lunar Reconnaissance Orbiter (LRO) has received a science extension and is being transferred to PSD; the Artemis/Themis satellites are being moved toward the Moon to study solar wind interaction. Lunar missions LADEE (study of lunar dust characteristics) and GRAIL (lunar gravity measurements) are on track. An International Lunar Network (ILN) is under study to provide 4 anchor nodes for studying seismic and heat flow phenomena on the Moon. Within the Mars program, Odyssey, Mars Reconnaissance Orbiter (MRO), and the Mars Express missions are all working well. The Mars Science Lander (MSL) is moving toward launch in late 2011. A Mars aeronomy mission, MAVEN, is scheduled for 2013, the ESA Trace Gas Orbiter for 2016, and much discussion is ongoing with ESA for a Mars Sample Return (MSR) in the 2020-and-beyond timeframe. After 2012, a new set of planetary missions will likely be in progress, pending Decadal Survey release. Dr. Green noted that the Exploration Systems

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Mission Directorate (ESMD) has not discussed missions beyond going to an asteroid in 2025, in reference to a question on future Mars missions.

Discussion

Dr. John Rummel asked about the planetary protection costs associated with the use of advanced Stirling radioisotope generators (ASRGs) in the Discovery program, generally thought to be \$17M. Dr. Green explained that the Discovery selection would give investigators an opportunity to fly a new ASRG (30% efficiency vs. 6% for RTGs) power system that will be government-funded. He acknowledged that the mission will have to pay the accommodation costs for planetary protection. He also noted that there will be other power system development opportunities under the new Office of the Chief Technologist (OCT), and that in the Discovery program, the launch vehicle would not be included in the cost cap. Ms. Gabrynowicz pointed out that missions must adhere to the United Nations (UN) Principles on Nuclear Power Sources. Dr. Green noted that he was aware of these principles, and that in addition NASA follows U.S. government regulations on launches with radioisotopic power systems. He added that 2010 is the critical year for a re-initiation of Pu-238 production; if it is not made available soon, PSD may have to move the next Outer Planets Flagship (OPF) mission to the right. Dr. Andrew Steele asked if PSD were investing in other technologies for power generation such as solid-oxide fuel cells. Dr. Green replied that the division was investing \$100M per year in alternative power sources for short-lead technologies. OCT will support long-horizon advanced technologies. Asked if the Mars Scout program was still in existence, Dr. Green replied that while Scout missions are no longer available, PI-led teams may now propose Mars missions for each announcement of opportunity by in the competitive Discovery program. New Frontier is also a PI-driven program. Dr. Rummel asked if there would be a planetary protection accommodation review for U.S. instruments on the ExoMars mission. Dr. Green took an action to answer this question.

In response to a question on how the Arecibo facility would be funded, Dr. Green noted that in FY10, NASA is paying a \$2M earmark for Arecibo. If the FY11 budget passes, NASA will pass \$2M of this funding to Arecibo for NEO observations, but will also request some priority time for usage. Goldstone's future depends on the SMD relationship with the Space Operations Mission Directorate, which oversees the Deep Space Network. The current plan is to operate Goldstone to 2020-25; in the meantime, SOMD is upgrading its capability with a multiple 34-meter array to replace the 70-meter antenna.

Outer Planets Missions

Dr. Curt Niebur presented a summary of Outer Planets (OP) mission activities. NASA has approved the Cassini Solstice mission, a second extension of the Cassini mission, which is funded at a somewhat reduced level. The extended mission contains a similar set of science objectives to previous ones and will run out to 2017 to monitor Saturn for its seasonal variations, as well as Titan and Enceladus. These observations will cover almost a full Saturnian year when coupled with previous spacecraft observations. The extended mission will be subject to periodic Senior Reviews. The Cassini team has been regularly posting relatively raw data, and is currently addressing discrepancies in data tools output, working on updating guides/algorithms, and is examining the utility of a metadata library. NASA is also discussing the addition of new participating scientist with ESA. The project has replaced a number of co-investigators on the U.S. side, and is in the process of doing this on the ESA side. Dr. noted that despite an original 4-year lifetime expected for the Cassini mission, its only limitation has been hydrazine fuel, which will be depleted by 2017. The spacecraft is healthy, and has experienced only minor glitches which have been successfully addressed. Informally, the end-of-mission scenario for 2017 entails direction of the spacecraft into high-inclination, proximal orbits around Saturn for ultimate spacecraft disposal.

Next OP Mission

NASA and ESA have been using a multi-step process to select the next joint OP Flagship mission, which began in 2007. NASA studied several mission concepts as did ESA. In 2008, merged efforts were down-selected to a NASA concept, the Europa Jupiter System Mission (EJSM) and ESA's concept, a Titan Saturn System Observer. Each agency carried out parallel, independent studies, and provided observers for each study team. The two missions are similar in all but risk. The Titan Saturn System observer was deemed as high in technical risk compared to EJSM, thus NASA and ESA prioritized EJSM as a mission for the first opportunity, with a Titan Saturn System Observer to be developed as the next opportunity. EJSM is being studied by a joint NASA/ESA Science Definition Team (SDT). As currently conceived, NASA would supply a Jupiter/Europa Orbiter, and ESA would provide a Ganymede Orbiter. Before reaching their final destinations, the two spacecraft would jointly explore the Jupiter system. The use of two spacecraft will provide synergistic data on Io's volcanoes, Ganymede's magnetic field and Jupiter's atmosphere and magnetic field. The joint SDT is also considering the observation of other icy satellites in the Jovian system. Flybys can be incorporated as the tour allows. A notional timeline for EJSM is for a 2020 launch, pending Decadal Survey results and budget runouts.

The Jupiter Europa Orbiter (JEO) will investigate the habitability, space environment, and oceans of Europa, and will also explore Jupiter as an archetypal gas giant. The orbiter will launch on an Atlas V 551, with a 6-year cruise time, the use of multi-mission RTGs (MMRTGs), and a payload of about 11 instruments. The spacecraft is not mass-constrained at this point. The current cost estimate for the NASA side of the mission is \$4B in real-year dollars. The Europa science campaigns will span 9 months. The initial orbit will be 200 km, during which time the instruments will perform global characterization, followed by a 100-km orbit take higher resolution measurements in chemistry, composition, and imagery. The last phase will be characterized by a targeted campaign, examining 1400 coordinated targets that will be identified during first and second phase of the mission campaign. Dr. Steele asked how the mission could remain discovery-responsive with such a high data volume. Dr. Niebur replied that the mission would release data as quickly as possible to address this feature of the mission. The mission will also adhere to Planetary Data System (PDS) standards and policies for archiving. Dr. Karen Buxbaum asked if the mission would be using any innovations in its operations approach. Dr. Niebur responded that the mission is not expected to see lot of unique sequences as in the Cassini/Galileo missions; the mission would pick one of a few scenarios and then run it. Dr. Gerhard Schwehm observed that there are still issues with ESA proprietary data rulings. Dr. Niebur acknowledged the existing tension between proprietary matters and a rapid response to broader science community. He felt that the resulting mission data would accumulate in such volume that data reduction will be a long-lived effort. Ms. Gabrynowicz suggested that Dr. Niebur contact the US Geological Survey (USGS) Sioux Falls archive. Dr. Victoria Hipkin commented that PDS has been very successful in archiving spacecraft data as far back as Mars Mariner. Dr. Levy felt that validating and collating data would be a bigger challenge for EJSM and asked how much of this problem had been thought through. Dr. Niebur thought the mission would probably task validation and collation to the instrument providers. Science teams will have to develop these procedures for assimilation of data for operations continuation. The target database is expected to be populated before orbiter gets to Europa. The last phase of the campaign may also be extended; it is hard to predict when radiation will actually kill the instruments. Dr. Hipkin suggested that Dr. Niebur consult with the Mars Phoenix lander team, as well as MRO, to learn lessons on data-streaming.

The JEO radiation challenge entails 2.9 megarads of exposure. The mission has adopted an approved systems engineering approach. Key radiation-hard parts are already available for JEO, with required heritage. As presently conceived, JEO would receive a similar dose at end-of-mission to what Galileo survived over its extended mission. JEO will have much more radiation shielding and more radiation-hard parts than Galileo. Planetary protection requirements for JEO are currently surmised to be at category III, but formal requirements are not yet set for the baseline mission. The approach to compliance demonstration will depend on the mission phase. A combination of analysis, pre-launch thermal

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sterilization methods, and post-launch sterilization by Jovian radiation environment will be used to help achieve compliance. The impact speed will not be high enough for impact sterilization.

The Jupiter Ganymede Orbiter (JGO) will focus on Ganymede geology and habitability, and will utilize a highly elliptical orbit to measure the magnetosphere, followed by circular polar orbit to map surface. The orbiter is an L-class mission for ESA (about US\$1B). JGO will offer rich opportunities for Jovian science. Overall, the sum of the two craft exceeds the parts; EJSM can perform radio occultation science and explore Io volcanism, among many other abilities. The biggest challenge for integration will reside with any instrument provider that provides instruments to both spacecraft. Collaboration between the agencies is close and issues are now being worked in pre-phase A. Integration will take place between the two agencies, keeping in mind the slightly different schedules between NASA and ESA.

While awaiting the outcome of the Planetary Decadal Survey, NASA will continue to fund efforts to reduce cost risk for this mission through studies and analysis, and will initiate a two-step instrument selection process (instrument AO scheduled for 2011). NASA is also working on Radiation Mitigation Plan, engaging the community on science content, and preparing for AO release by holding instrument workshops in both Europe and the U.S. A final instrument workshop will be held in July in the U.S. The AO will follow the Cassini/Huygens example, with final flight instrument selections to be carried out jointly by ESA/NASA. The Europa AO will be released some months before the Ganymede AO to accommodate the longer review period for NASA. The U.S. spacecraft assignment is tentatively planned for NASA Jet Propulsion Laboratory (JPL). Dr. Niebur observed that while either mission is robust enough to fly on its own, NASA and ESA would prefer to execute the mission in tandem.

Special Government Employee Ethics Briefing

Mr. Michael Monahan presented the annual ethics briefing to the subcommittee.

Update on COSPAR Outer Planets Workshops

Dr. John Rummel reviewed results from two 2009 workshops regarding planetary protection for Outer Planets satellites, as well as ethical considerations. The Workshop on Planetary Protection for Outer Planet Satellites held in Vienna, Austria, in early 2009, focused on updating the body of knowledge, classification of bodies, and specific parameters of upcoming Outer Planet Flagship missions. The workshop used recent Space Studies Board analyses as a framework for decision-making. COSPAR also used an NRC Small Bodies report in determining how to classify small bodies in terms of sample return and forward contamination. These bodies are generally considered at Category I and II levels, but are considered on a case-by-case basis. Categories III/IV are the rule for certain outer Solar System satellites, including Europa. The workshop also considered the contents of the COSPAR Mars Special Regions Colloquium. Other considerations brought to bear on categorization included sources of ionizing radiation in space, surface temperature of satellites, the existence of liquid water, the potential for exchange of material between surface and liquid regions, and the Coleman-Sagan equation. In sum, the workshop concluded that S-type asteroids are not of scientific interest, PDC-type asteroids are of interest but with contamination concerns; Europa remains a Category III/IV destination; and Ganymede, Titan, and the Pluto/Charon system all bear concern for some contamination.

There seems to be consensus in the science community regarding the ranking of Outer Planet satellites as objects of scientific interest; Titan, Ganymede and Callisto all appear to attract a similar interest level coupled with caution for contamination. This interest engendered a second meeting, a Workshop on Titan Planetary Protection, held in Pasadena, CA in late 2009, which considered planetary protection categories for Titan and Ganymede. The workshop explored the concepts of icy world habitability, temperature, and the probability of biota in sunless worlds (considering a recent discovery of metazoans on Earth thriving

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in anoxic conditions). The workshop also focused on Ganymede resurfacing phenomena and other parameters; the low likelihood of appreciable heating on Titan; a discussion of deep ocean presence on Titan; and models of Titan's interior. A 2000 Space Studies Board report had made specific recommendations on avoiding the forward contamination of Titan, which were also taken into consideration. NASA has accepted most of these considerations for Category III/IV requirement for Europa; additional COSPAR language adds that bioburden reduction will be necessary for Europa landers and orbiters. In general, it is accepted that the probability of contamination needs to be less than 1×10^{-4} per spacecraft. The workshop also developed an extensive list of proposed categorizations for target body/mission types for Outer Planet satellites, Kuiper Belt objects, asteroids, icy planetesimals, etc., based on conservative assumptions and calculations. Planning is now under way to hold an Ethical Consideration Workshop at Princeton University in June 2010 to further elucidate a philosophy on planetary protection of outer Solar System bodies.

Asked how the specific bioburden quantitation arose, Dr. Rummel explained that the number arose from international consensus dating as far back as the 1960s, based on judgments of how well one must protect a body while actually exploring it. PPS members debated the sensitivity of Europa to contamination and the problem of transport of materials between ocean and surface. Some felt Europa's irregular surface might support survival of microorganisms while others felt that there was little probability of life propagation at cold temperatures. There was some disagreement among members as to mechanisms of connection between ocean and surface, and some members urged more caution in categorizing Europa. Dr. Buxbaum asked if the draft proposal for Titan used the same Coleman-Sagan calculation that was performed for Europa. Dr. Rummel replied that Titan was considered a category II with caveat on possible contamination, to be determined statistically. Dr. Michel Viso commented on the natural flux of matter in space, which would engender taking particular care in protecting the returning sample.

Planetary Protection for Icy Moons: Updating the SSB Europa Report

Dr. Conley presented particulars on a NASA letter requesting efforts in updating Space Studies Board (SSB) recommendations (2000) on protecting Europa from forward contamination, first reviewing aspects of the original report. In particular, planetary protection must be reviewed for the 2018 launch of EJSM. An update request could include a review of the SSB Europa report, incorporating conclusions from the recent COSPAR workshops on planetary protection for icy bodies, and expanding previous SSB recommendations to cover the wide range of icy bodies, with specific points to call out, such as suggested scientific investigations to refine risk assessment, technology developments, and possible factors that could be used in a Coleman-Sagan formulation. This letter will be briefed to the Science Mission Directorate (SMD) Associate Administrator (AA) in short order. Dr. Conley invited PPS to comment and enlarge upon the request. Ms. Gabrynowicz suggested placing a discussion of Article IX of the Outer Space Treaty up front. A SSB representative at the meeting commented that comments were welcome, and advised Dr. Conley to select items that could be acted upon in a timely manner.

NASA-ESA Planetary Protection Collaboration

Dr. Gerhard Knimek presented an update on ESA/NASA efforts in planetary protection. A dedicated letter of agreement (LOA) between the two agencies was devised to formalize planetary protection efforts, allow cooperation on policy requirements, enable designation of representatives, enable the conduct and coordination of research, and allow exchange of relevant documentation. The LOA was signed in 2007 and is valid through 2013. A dedicated technical assistance agreement was also established between JPL and primary signatories in Europe to further support the effort; this agreement was signed in 2008 and is valid through February 2018. Under the agreement, the mission lead organization bears overall responsibility for compliance, and the PPO of the lead organization determines the planetary protection category in coordination with COSPAR and the PPO of the partner agency. The PPO of the

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partner organization assigns and approves requirements for flight elements of the mission. Planetary protection courses are also offered under the joint agreement. The course is typically a 2.5-day class covering regulations, implementation of requirements and laboratory practices. The next course in will be held in Harwell, UK in June 2010, and will be tailored to JEO/JGO requirements.

Formal and informal coordination meetings between NASA and ESA take place regularly, and include assessment of medium- and long-term activities for planning, and short-term activities focused on calls and invitations. Follow-up activities related to planetary protection are also carried out, such as establishing hydrogen peroxide or rapid microbial detection specifications. These activities help to ensure consistency of data forms. Dr. Steele noted in this context that NASA ESMD has yet to sign off on new techniques in molecular microbial detection, constituting a considerable roadblock for planetary protection technology at NASA. Dr. Conley noted that ESMD has different requirements than SMD, but recognized the disparity in techniques is a challenge; SMD is trying to develop a framework to move the technology forward. Dr. Mary Voytek observed that when dealing with low biomass, it is difficult to cross-calibrate methods, but also asserted that the Planetary Protection Office is making a diligent effort to move forward; the issues are both technical and budgetary; in addition, techniques must clearly demonstrate utility. Dr. Steele recommended that PPS invite a briefing from a European representative to highlight the usefulness of molecular methodology. A Space Operations Mission Directorate (SOMD) representative commented that NASA must first obtain community agreement on what is “good enough,” but agreed that a discussion with ESMD is necessary. Dr. Buxbaum added that molecular methods must be understood in terms of what they actually measure, and that the information they yield must jibe with policy requirements and must be standardized; e.g., genomic methods do not show how many organisms are on a spacecraft. She added that advice from SSB can be intellectually rich and highly idealized, but not operationally realistic. NASA needs more practical advice.

Dr. Kminek continued the presentation, acknowledging that efforts in microbial detection are taking years to standardize. ESA and NASA are carrying out joint research and development (R&D) activities on quality assurance specification for planetary protection assays, and qualification of alternative assay procedures. Implementation and documentation to verify planetary protection requirements is expected to be available by the end of 2010. The two agencies are also engaging in joint reviews of research proposals and support for workshops.

Dr. Kminek reviewed the organizational structure at ESA governing planetary protection. The Director of Technical and Quality Management (including safety) holds the overall responsibility for planetary protection, holding science as an equivalent concern. A Planetary Protection Working Group (PPWG) provides advice directly to the chain of command. The duties of the ESA PPO include those similar to NASA’s counterpart. Terms of reference for the working group are used to formulate and update planetary protection policy and requirements. The PPWG currently has 14 members, and the PPO also functions as the Executive Secretary for supporting the chair of the PPWG.

ESA has just signed an agreement with the European Science Foundation (ESF) (analogous to NRC) to provide independent strategic advice on specific planetary protection matters. The first task for ESF will be to propose an acceptable risk level for the general (global) public with respect to potential contamination to the terrestrial biosphere from Mars Sample Return (MSR). Its first report is expected in Fall 2011 in preparation for the COSPAR General Assembly in 2012. Dr. Voytek asked if ESF would provide a qualitative assessment for MSR, as specific numbers in order to establish engineering requirements for the containment system. Dr. Kminek felt that ESF’s wide range of expertise, in both social and hard sciences, and in risk assessment, would make such an assessment possible. He noted also that ESF has been encouraged to interface with SSB-NRC. Dr. Perry Stabekis recommended inclusion of nuclear and genetic engineering experts for the MSR task. Dr. Rummel raised the issue of risk balance and how this could be effectively communicated to the public. Dr. Baecher felt that the field of risk

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assessment is relatively mature and that the public simply should be informed of the risk standards. Dr. Levy disagreed, asserting that risk for the global population is not dealt within most risk analysis studies. Dr. Pieters commented that there is no such thing as an acceptable risk, and that MSR risk would need to be stated in another way. Ms. Linda Billings referred to a body of Department of Energy (DOE) work on risk communication that one might take into account, including data on the power of stigma and emotional content. She added that timely, accurate, and complete information will be necessary; and that the public must be included in the decision-making process. Ms. Billings agreed to write an action plan for Dr. Conley. Dr. Bernstein agreed to provide presentations and useful items on an internal website. Dr. Levy felt it would be useful to consider past public outcry over the minimal risk of Galileo mission. Dr. Conley invited suggestions for future agenda items regarding the ESA/NASA collaboration.

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Dr. Levy briefly reviewed the agenda for the day.

Mars Program Overview

Dr. Michael Meyer provided an overview of the Mars Exploration Program (MEP), reviewing the mission portfolio for 2009, including the selection of the MAVEN Aeronomy mission for 2013 and the re-scheduling of MSL for 2011. In 2010, a Senior Review was held to review proposals for extension of Odyssey, Mars Exploration Rovers (MER), Mars Express and MRO. If the MER Spirit rover survives the martian winter, it will be treated as a static platform to continue to perform science *in situ*, and the still-mobile Opportunity will continue its progress on the surface. Mars Express subsurface sounding will continue with a reduced analysis budget, and MRO funding will not be reduced significantly. For planetary protection consideration, MEP must decide whether to boost Odyssey's orbit to meet planetary protection lifetime requirements. MER and MRO are currently in compliance; and MSL successfully passed its PPO December 2009 review (sampling and bioassay activities are continuing at a low level). The MAVEN aeronomy mission has formulated preliminary orbital calculations and will probably follow MRO parameters.

MSL

The Mars Science Lander (MSL) will carry ten instrument packages, including a gas chromatograph/mass spectrometer to measure organics, minerals and isotopes; high-resolution imagery equipment, a descent imager; a meteorological station; and instrumentation to measure spectra of radiation on surface, and water distribution by measurement of neutrons. MSL remains scheduled for a November 2011 launch. Recent experiments on terrestrial desert perchlorates imply that there may be 5-10 ppm of organics on Mars; MSL will help to confirm or refute these results. MSL landing sites under consideration are Eberswalde, Gale and Holden craters, and Mawrth Vallis. The project has baselined the option of adding a new site (E Margaritifer or NE Syrtis) by early summer 2010.

The President's FY11 budget allows MEP to reach a sustainable level. Changes to ESMD to embark on new human space exploration focus have also identified Mars as the ultimate destination as a driver for technology development. Six internal teams have been established to study robotic precursor missions for this purpose. The Exploration Precursor Robotic program will receive \$3B over 5 years, and is expected to initiate at least 2 missions in FY11. Candidate missions include lunar follow-ups missions to the LRO/LCROSS missions, and reconnaissance of near-Earth bodies such as asteroids.

Joint NASA/ESA Mars Exploration

After some interval of budgetary issues for both ESA and NASA, the two agencies agreed to split future ExoMars objectives across two opportunities in 2016 and 2018. NASA is providing the launch vehicle

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and ESA is to provide the orbiter, based on an agreement endorsed by both agencies in December 2009. ExoMars will set the stage for MSR. A management structure has been established, including a Joint Executive Board, Joint Engineering Working Group, and a Joint Mars Architecture Review Team. An MSR working group has also been established. The 2016 mission will be an ESA entry, descent and landing (EDL) demonstration, with NASA contributing instruments. The instrument call went out on January 15th, and a joint selection announce will be made by October 2010. The 2018 opportunity will send a NASA mid-sized rover (250-350 kg) and the ESA ExoMars rover to the surface of Mars. The NASA rover will cache samples for future sample return and will also perform primary astrobiology. The ESA rover will drill into the subsurface to a depth of 1-2 meters. Dr. Rummel commented that the mission plan doubles vulnerability in planetary protection. Dr. Buxbaum assured PPS that the Mars program at JPL retains a planetary protection representative in all aspects of planning. Dr. Dale Griffin asked if the mission would carry any microscopes, adding that simple and inexpensive epifluorescent microscopy would be able to clearly identify bacteria. Dr. Meyer stated that while MSL will not carry a microscope, the suite of instruments for the 2018 opportunity is not yet determined. He also cautioned against setting mission specificity so high that sensitivity is compromised.

Caching is the key concept for the 2018 Mars opportunity. Key milestones include a recent Concept Feasibility Review completed in March 2010. A Mission Concept Review is due in December 2011. Dr. Pieters asked if the ESA rover would do some characterization studies. Dr. Meyer explained that ExoMars is already designed, and that a science analysis group will make further decisions, and there will be further planning and interaction for the rovers. Dr. Steele added that subsurface samples would be of the highest scientific interest. Dr. Meyer felt that it was still possible to include this in MSR.

NASA MEP and ESA are continuing to develop plans for a Joint Trace Gas Orbiter in 2016, while planning for a joint MSR mission in 2020 and beyond. A multi-element concept is envisioned for sample return, which will dilute the technical challenge, keep mass requirements down for the EDL system, spread the budget over 1.5 decades, and establish stable sample states on or around Mars after completion of each element. The cost is estimated to be \$7B. Functional steps to retrieve a sample will be split into three different launch opportunities, including ongoing maintenance of an orbital relay infrastructure. Dr. Rummel noted that sample and curation facilities must be complete well before MSR takes place. Dr. Hipkin commented that this requirement is recognized in the international iMars report. Dr. Pieters asked if there would be more than one opportunity to cache a sample. Dr. Meyer responded that the number of caches depends on funding. The Decadal Survey calls for 2 caches on a 2018 rover; MEP is currently planning for one cache, and one cache is postulated per opportunity. Dr. Hipkin recommended having some sort of science measurement occur in each step/opportunity, making the plan more palatable for the community. Dr. Meyer observed that a rover would have to perform science on-site in order to choose a scientifically valuable sample for retrieval. Dr. Pieters expressed concern at having only one shot at one cache; and that multiple cache opportunities are inherently better. Dr. Meyer noted that a 2007 NRC report supported sample return as fuel for further exploration, and that science instruments can also be incorporated on relay orbiters. Dr. Stabekis felt that the mission scenario penalized science. Dr. Meyer pointed out that the joint program is comprised of an open architecture, and that other international agencies will be able to make additional contributions. NASA and ESA are focused at present in trying to build a plausible program. Asked about sample handling during the cruise/return phase, Dr. Meyer reported that the program was working more on stabilizing reentry into Earth atmosphere. Science results that show greater distribution of water ice on Mars will help inform future sites with interesting subsurface features that suggest buried water ice down to the tropics. The subcommittee debated the implications of the Special Regions Report for these sites. Dr. Meyer noted that the mission is not planning to impact sites that contain water ice, but a rover might be able to reach one. He summarized the presentation by noting program progress, future implications of the Decadal Survey, and possible partnering with ESMD for robotic precursor missions.

Q&A with Ed Weiler

SMD AA Dr. Weiler described his recent experience with Congressional briefings and reported a very cordial reception for the NASA science program. He welcomed a stable budget for PSD, noting that the Earth Science Division's large increase has replenished its grievously underfunded program. The SMD program is not under attack. Dr. Weiler acknowledged concern and uncertainty over the effects of a Continuing Resolution, but noted with satisfaction that the Mars program has been revitalized and back on track for future missions, thanks in part to the partnership with ESA to support a fully joint Mars program. Together, NASA and ESA possess a viable budget with reserve. Dr. Levy congratulated Dr. Weiler on achieving an unprecedented level of cooperation. Dr. Hipkin commented that the Canadian space agency welcomes the agreement and hopes to make a contribution. Dr. Steele asked whether the effects of International Trafficking in Arms Regulations (ITAR) and the difficulty of funding foreign nationals could be ameliorated. Dr. Weiler replied that while ITAR not under NASA control, there is hope that the current administration may be able to remove obstacles. Even if ITAR does not change, NASA has found ways to work with ESA, as evidenced with ESA interactions on the James Webb Space Telescope (JWST). Dr. Levy alluded to a Working Group within the Department of Commerce that is working on the issue. Dr. Meyer reported that MEP had successfully established a joint review of proposals for the 2016 Orbiter. Dr. Weiler noted that funding of foreign nationals can be indirectly accomplished through residence at U.S. universities, but acknowledged that this new level of collaboration would entail new mechanisms for communication.

Dr. Weiler welcomed the re-convening of PPS and the streamlining of the NAC Science Committee, and assured the PPS that its voice would be heard. Dr. Rummel noted that since 2006 the planetary protection research budget has atrophied, and that it might be time to "tax" the programs again. Dr. Weiler left that issue to a potential PPS recommendation, and also suggested that ESMD be brought into the discussion. Dr. Weiler suggested that the subcommittee consult directly with Doug Cook of ESMD, and Robert Braun of the OCT. He added that he would argue that PPS should report directly to the NAC or to the NASA Administrator. Dr. Steele called for more cross-cutting representation for planetary protection, including within the newly established OCT. Dr. Weiler agreed with this assessment.

Assessment of Planetary Protection Requirements for Mars Sample Return Missions (NRC/SSB report)

Dr. Jack Farmer presented a briefing by teleconference, summarizing a Planetary Protection Report from the NRC, in response to a request from NASA SMD, addressing the major concern of returning living entities from Mars in a sample return mission, including scientific investigations that should be performed to reduce the probability of such a return.

Dr. Farmer reviewed changes made in NRC's assessment of Mars Sample Return since its 1997 report, taking into account discoveries revealing the expanded habitability of regions on Earth, advances in biosignature analysis that have yielded new insights, increased understanding of epidemics/pathogenesis, new discoveries that suggest increased presence of water on Mars, and studies of extraterrestrial materials that have expanded the understanding of the potential for material exchange. Changes in technical policy have also occurred. The Mars community has grown larger and encompasses a broadened mission scope, lessons learned in sample handling, internationalization of Mars sample return, new technologies for nondestructive biosignature detection, and an increase in the number and public acceptance of biocontainment facilities. The major conclusion of both the 1997 and 2009 reports focus on the need for sample containment. While there is consensus agreement that the probability of contamination is low, it is not zero. Samples should be sequestered until they are determined to be nonhazardous to life on Earth.

Dr. Farmer reviewed updated technological measures to prevent sample release: canisters should remain sealed through all mission phases, through transport to facility, where they can be opened under strict

containment. The 2009 report also recognizes the need to move samples, under containment, to several different facilities for appropriate analysis. The potential for living entities is based on current knowledge and ongoing studies. The report concluded that NASA should maintain a conservative approach of planetary protection for MSR. Furthermore, no uncontained martian materials, including spacecraft surfaces, should be returned to Earth unless sterilized. NRC has also called for further science investigations to reduce uncertainties, include remote sensing and *in situ* studies on Mars, analysis of martian meteorites, studies of prolonged viability in geological and ancient materials/fossils, determination of metabolic diversity and environmental limits of microbial life on Earth, and further development of laboratory-based and *in situ* approaches to biosignature detection (the latter considered one of most important points).

The report also recognizes the potential for large-scale effects on Earth's environment, leading to a call to maintain a conservative approach to both containment and test protocols. Dr. Farmer expressed a personal concern regarding insufficient data on ecological effects. While the potential for ecological impact is low, additional study is needed to really understand it.

Criteria for intentional sample release include provision of a detailed protocol, which must be clearly articulated before sample return occurs. This protocol must undergo regular updating and oversight. International partners should also be part of these protocols and oversight. Future protocols should consider sample heterogeneity in order to avoid sampling errors and false negatives, and development of definitive chemical mapping methods. The best nondestructive methods must be identified for mapping samples at the microscale. Sample characterization will require development of secondary containers for transport.

Planning for a dedicated Sample Receiving Facility (SRF) should be included in the earliest phase of a Mars return mission- i.e., now. No facility currently exists that combines all the necessary elements of an appropriate SRF for Mars sample return. Construction and commissioning of a SRF should be complete and fully operational at least two years prior to sample return, to allow ample time for testing and integration of instruments and test protocols at the facility. The SRF should employ a multidisciplinary team of scientists to perform a rigorous battery of tests on samples. An independent science and technical advisory committee, with oversight responsibilities for materials returned to Earth from Mars, should also be constituted. To ensure independent oversight, PPS or an equivalent group, and the PPO, should have more direct routes of communication, responsibility and authority within NASA to clearly articulate planetary protection requirements. Lastly, the report concluded that public engagement is critical- the public must be informed about all aspects of Mars sample return.

Discussion

Dr. Voytek commented that integrity of sample materials collected is also considered to be critical. Dr. Farmer replied that the report panel did discuss this issue but did not go into detail. He agreed that protecting the integrity of sample is fundamental, and this will be taken into account through nondestructive methodology. Dr. Pieters asked how samples would be proven to be nonhazardous in a way that would be useful to the scientific community. Dr. Farmer noted that specific criteria had not addressed by the report, but agreed it was an important point. He added that intentional release of samples needs to be fleshed out, and expected the decision path to be addressed by future committees. Dr. Doran asked if NRC had considered the case that the sample cannot be released. Dr. Farmer agreed that this stipulation needed to be included in a future protocol. Dr. Rummel noted that there are national security regulations that deal with any governmental action that could affect the environment, and which requires representation from the Environmental Protection Agency (EPA). He referred to a published Draft Protocol (http://spacescience.nasa.gov/admin/pubs/marssamples/draft_protocol.pdf) that is publicly available, and added that there is room to further develop specifics of this protocol. He felt that NASA

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must get started on this quickly. Dr. Viso added that the SRF will likely be multiple facilities, and presumed that the EU will undertake a large effort as well; he expected a strong European demand for sharing of responsibilities for sample. He added that the decision-making must be shared between agencies, and that furthermore there may also be a diversity of techniques for analyzing the sample. Dr. Levy felt that a Working Group on sample handling and analysis distribution might be warranted. Dr. Farmer noted that the NRC report takes ESA representation into account.

Dr. Hipkin observed that the Draft Protocol recognized that the first steps of sample analysis are science, thus there may be an element of investigation and protection in the same steps conducted at the SRF, reflecting the need for specific scientific expertise in the facility. Dr. Levy cautioned against the formation of an elite science corps with exclusive access to the sample. The subcommittee discussed ramifications of subsample packaging, and the possibility of transporting back to Earth a viable martian bacterium. Dr. Viso cited the Stardust examination team as a good example of international cooperation. Ms. Gabrynowicz emphasized bringing in biological expertise early on to avoid an appearance of negligence.

General Discussion

Tentative meeting dates were discussed for the mid-August period. Dr. Gary Lofgren commented by telephone, following up on the sample return discussion, commenting on the utility of the Apollo program as presenting useful procedures for processing a sample. Apollo sample processing methods included basic mineralogy and limited chemical analyses to provide characterization of samples, all of which were carried out in a well-choreographed way. Dr. Levy highlighted the importance of the biological characterization, but acknowledged that mineralogy is important information for the biologists as well. Dr. Penny Boston commented that within her own cave research protocols, she used a ranking system that employed the most- to least-sensitive analysis techniques. For biological assays, it is important to perform the most sensitive (microbial) analysis first. PPS members agreed that the analysis team should include the entire complement of expertise, geologists and biologists included. Dr. Lofgren added that both groups should also be continually observing the sample handling.

Dr. Levy considered recent changes in the NAC Science Committee and noted that he would seek ways to consistently communicate with the NAC and to ensure that recommendations are not lost. He also requested suggestions for a “living list” of issues for the PPS agenda which have the potential to become formal recommendations. Moving on to potential issues, Dr. Levy listed the issue of committee structure, the inclusion of planetary protection review in the MSR mission, the vision for human exploration, and planetary protection funding revitalization as realized through taxation on other NASA divisions. Dr. Rummel reiterated the importance of retaining resources and support for the PPO, coupled with the SMD AA being ultimately responsible for planetary protection in NASA, with PPO as designee. He added that the reporting relationship of the PPO must be clear and direct; and that the control of resources of the PPO should not be regulated by the PSD. In addition, he cited the need to continue to cooperate with ESA beyond 2013, and to initiate an SRF as soon as possible. Dr. Lipps suggested establishing a “place” for planetary protection within the agency, and also within the international community, to enhance function, and to embrace different points of view within these communities (a COSPAR function vs. a joint WG ESA/NASA). Dr. Rummel noted that the ESA PPWG has representation from NASA, and that COSPAR regularly conducts workshops. He noted however, that PPS is the only body that includes international representation in formulating advice for NASA. To this end, the PPS may perhaps formulate a specific recommendation for working-level planetary protection advice for the coordinated ESA/NASA program. Dr. Kminek felt it would be useful to exchange meeting minutes between the groups. Dr. Lipps also suggested formalizing regular PPO interactions and routinely reporting on them, to determine any policy or requirement gaps between the two agencies.

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Dr. Hipkin suggested including a briefing on Canadian activities in planetary protection as an agenda item for the next meeting. Dr. Buxbaum and Dr. Conley suggested holding a half-day tutorial before each PPS meeting to educate new members on planetary protection matters. Dr. Levy recommended developing the PPO Website into both a tutorial and referential resource. Dr. Bernstein added ESMD and OCT reports to the meeting agenda, as well as a briefing on risk communication. PPS briefly considered responsibilities for planetary protection for US instruments/spacecraft on international missions. There was some disagreement as to where some responsibilities lie, engendering a discussion for identification of appropriate regulatory bodies/agencies that could provide this information, including the Department of State and the Federal Aviation Administration (FAA).

Dr. Conley provided brief details about the Phobos-Grunt Russian/Chinese mission to Mars, launching in 2011, the goal of which is to bring back a soil sample from the Mars satellite, Phobos. The mission is designated as Russian category V (returnable mission). Phobos has been assessed by SSB as probably unrestricted for Earth return. Another passenger on the Phobos-Grunt is an experiment from the U.S. Planetary Society called the Living Interplanetary Flight Experiment, or LIFE, which will send 10 types of microorganisms and a natural soil colony of microbes on a three-year round trip in order to determine survival. To Dr. Conley's knowledge the Planetary Society microorganisms have already been sent to Russia for incorporation into the payload. COSPAR has recommended that the Russian Academy of Sciences reassess the mission. The Russians will treat the sample as a BSL-4 material. NASA's PPO feels that the contamination probability is very low. NASA has been asking for orbital lifetime characteristics (expected in the October/November timeframe; this was added as a possible agenda item for the next PPS meeting). If Russia does not follow COSPAR recommendations, NASA and ESA will cease to support the mission. NASA has also been trying to contact the Department of State to determine responsibility for the Planetary Society payload. While initial analyses indicate that the mission is compliant with planetary protection requirements, ESA and NASA are trying to perform the required analyses to further inform planetary protection needs re: COSPAR requirements. Ms. Gabrynowicz pointed out that the U.S. is liable under both Article VI and IX of the 1967 Outer Space Treaty. PPS debated the need for a finding regarding this dilemma. An update on Phobos-Grunt was noted as a future agenda item, as well as a presentation on a potential ESA/NASA sample return working group. Dr. Viso suggested preceding such a working group with the formulation of a Roadmapping Committee. Dr. Hipkin noted in this context that smaller international agencies have zero visibility, thus the planetary protection effort should be more inclusive, making it truly international.

Future issues to be considered by PPS included SMD and ESMD coordination on practical standards to avoid forward contamination with both molecular and culture methods. Dr. Boston requested a tutorial on the propagation of daughter particles resulting from radiation, as well as transport mechanisms governing the interaction with materials; i.e. a radiation physics tutorial/modeling of surface interaction. A briefing was also requested regarding the survival of biota on spacecraft surfaces on planetary bodies. An Outer Planets presentation by Ben Clark was also suggested. Ms. Gabrynowicz offered a briefing on commercial launch licensing. Dr. Conley took an action to discover the disposition of a PPO letter to SMD regarding non-NASA launch activities and the regulatory role of NASA. Dr. Hipkin suggested a new assay/sterilization methods/planetary protection technology update.

The subcommittee considered findings and recommendations and limited them to commentary on PPS's reporting structure, establishing a meeting schedule, and commenting on the need for adequate budgetary support for the PPO. Dr. Levy agreed to circulate drafts via email, for finalization. Dr. Levy adjourned the meeting.

Appendix A Attendees

Planetary Protection Subcommittee Members

Eugene Levy, *Chair Planetary Protection Subcommittee*, Rice University
Greg Baecher, University of Maryland
Penny Boston, New Mexico Tech
Colleen Cavanaugh, Harvard University
Catherine Conley, Planetary Protection Officer, NASA
Peter Doran, University of Illinois, Chicago
Joanne Gabrynowicz, University of Mississippi
Victoria Hipkin, Canadian Space Agency
Gerhard Kminek, European Space Agency
Robert Lindberg, National Institute of Aerospace
Jere Lipps, University of California, Berkeley
Carlé Pieters, Brown University
John Rummel, East Carolina University
Gerhard Schwehm, European Space Agency
Andrew Steele, Carnegie Institution
Michel Viso, CMES, France
Max Bernstein, *Executive Secretary PPS*, NASA

NASA Attendees

John Allen, NASA Headquarters
Marc Allen, NASA Headquarters
Lisa May, NASA Headquarters
Curt Niebur, NASA SMD
Doug McCuiston, NASA Headquarters
Dennis McSweeney, NASA OIIR
Greg Williams, NASA SMD
James Green, NASA Headquarters
Ed Weiler, NASA Headquarters
Andrea Razzaghi, NASA Headquarters
Karen Buxbaum, NASA JPL
Marian Norris, NASA Headquarters
Dan Woods, NASA SMD
Mary Voytek, NASA SMD

Non-NASA Attendees

Joe Alexander, NRC Space Studies Board
Linda Billings, George Washington University
Albert Glassman, Self
Dale Griffin, USGS
Perry Stabekis, Genex Systems

Appendix B
NAC Science Committee Membership

Eugene H. Levy (Chair)

Provost/Professor of Physics and Astronomy
Rice University

Dr. Gregory B. Baecher
Professor of Civil Engineering
University of Maryland

Catharine Conley, Planetary Protection Officer

Planetary Sciences Division
Science Mission Directorate
NASA Headquarters

Max Bernstein, Executive Secretary

Science Mission Directorate
NASA Headquarters

Colleen Cavanaugh
Biological Laboratories
Harvard University

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

Gary Lofgren
Lunar Curator and Planetary Geoscientist,
Johnson Space Center, NASA

Robert Lindberg
President and Executive Director
National Institute of Aerospace

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

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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

Carlé M. Pieters
Department of Geological Sciences
Brown 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
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

Penny Boston
Department of Earth and Environmental
Science
New Mexico Tech

Subcommittee Administrative Support:

Ms. Marian R. Norris
Management Support Specialist
Science Mission Directorate
NASA Headquarters

**Appendix C
Presentations**

1. Planetary Protection Status, *Catharine Conley*
2. Planetary Science Division Program Status, *James Green*
3. Special Government Employees Ethics Briefing, *Michael Monahan*
4. Mars Exploration Program PPS Briefing, *Michael Meyer*
5. Briefing on SSB Findings on Mars Sample Return, *Jack Farmer*
6. NASA-ESA Planetary Protection Collaboration, *Catharine Conley and Gerhard Kminek*
7. COSPAR Planetary Protection Policy and the Phobos-Soil Sample Return Mission, *Catharine Conley*
8. Europa Update, *Catharine Conley*
9. COSPAR Workshops and Context, *John Rummel*
10. Outer Planets Missions, *Curt Niebur*

Appendix D
Agenda

Planetary Protection Subcommittee Agenda

NASA Headquarters, Washington D.C.

Dial in # 1-866 631-9069, passcode 3062413

May 13, 2010

Room 3H46

9:00 am Welcome, Orientation, Introductions Max Bernstein and Marian Norris, HQ

9:05 am Words from the Chair Eugene Levy, Rice U

9:10 am Planetary Protection at NASA: Issues and Status Cassie Conley, PPO/HQ

10:00 am Planetary Science Division Overview Jim Green, PSD/HQ

11:00 am Break

11:15 am Outer Planets Missions Curt Niebur, Outer Planets/HQ

12:15 pm Discussion E. Levy

12:30 pm Lunch

1:15 pm Ethics Briefing Michael Monahan, Legal/HQ

2:15 pm Update on COSPAR Outer Planets Workshops John Rummel, COSPAR/ECU

3:00 pm Letter request to SSB on Outer Planets C. Conley

3:30 pm Break

3:45 pm ESA-NASA Collaborations Gerhard Kminek, ESA/C. Conley, NASA

4:45 pm Discussion E. Levy/M. Bernstein

5:ish pm Adjourn for the Day, Dinner

May 14, 2010

Room 3H46

9:00 am Overview of the Day E. Levy/M. Bernstein

9:05 am Mars Program Overview Michael Meyer, Mars Program/HQ

10:00 am Discussion with the Associate Administrator Edward Weiler, SMD/HQ

10:30 am Break

11:00 am NRC report on Mars Sample Return Jack Farmer by telecon, ASU

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12:00 pm Lunch

1:00 pm Discussion and Recommendations E. Levy/M. Bernstein

3:00pm Adjourn