NASA ADVISORY COUNCIL

Planetary Protection Subcommittee

June 8-10, 2015

NASA Headquarters
Washington, D.C.

MEETING MINUTES

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Robert Lindberg, Chair

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Amy Kaminski, Executive Secretary

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Introduction

Incoming NASA Advisory Council (NAC) Planetary Protection Subcommittee (PPS) Chair, Dr. Robert Lindberg, opened the meeting. The Executive Secretary of the PPS, Dr. Amy Kaminski, made preparatory announcements and provided logistical information about the meeting structure. There are six new PPS members: Drs. Tullis Onstott, Darla Goeres, Yulia Goreva, Nicholas Steneck, Michael Imperiale, and Meenakshi Wadhwa. Drs. Onstott, Goreva, and Goeres were present on the first day. Introductions were made around the meeting room. Ms. Joanne Gabrynowicz mentioned having recently testified on the subject of asteroid mining, noting that there is now language in a House bill approving such mining. Her testimony on the matter can be accessed in the files of the Congressional Record.

Planetary Protection Overview

Dr. Catharine Conley, Planetary Protection Officer (PPO), presented a background briefing on fundamental planetary protection issues, describing the wide-ranging and complex science and engineering, biological, societal, and legal implications of the subject. Planetary protection is important for preserving the ability to achieve NASA planetary science goals, which address the origin, distribution and future of life in the universe. NASA planetary science goals include an inventory of solar system objects and processes; the evolution of the solar system; the characteristics of the solar system that lead to habitable environments; how and where life could begin; and the characteristics of small bodies and planetary environments that pose hazards and or provide resources to humans. Planetary science also seeks to understand the chemistry underlying life's origins. Phenomena such as alkali vents, amino acids on meteorites, etc., likely contributed to the prebiotic chemistry of Earth. Evidence of complex chemistry can first be seen in the geological record at about 3.5 billion years ago, when evidence of rust (oxidation) and photosynthesis began to arise.

Organisms thrive in strange places— lichens can survive space exposure, as just one example. Several kilometers below Earth, one can find nematodes and simpler organisms that thrive on the radioactive decay of various ores. Microbes can survive on unusual energy sources such as sulfate, perchlorates (found on Mars) and photons, as well as energy from hydrothermal processes. Introduced organisms can have significant ecological impacts, despite the fact that most stable communities are resistant to invasion by novel species. However, pathogens such as *Salmonella typhimirium* express more virulence genes after culture in space, and such invading organisms can sweep through a community. Terrestrial microbes, under certain conditions, can grow in Mars-simulated chambers.

While the unaltered surfaces of most planets are cold and dry, interior environments may be more similar to Earth, and as such may contain hot and cold subsurface oceans,

and subsurface rock that might be capable of hosting life. Life is tough, tenacious, and metabolically diverse. Different habitats on Earth have very diverse microbial populations that survive in a wide variety of conditions. Contaminants in clean rooms come from a wide variety of sources: the atmosphere (*B. stratosphericus,* found in the atmosphere above 24 km), soil, hay, desert, rocks, deep subsurface locations, SAF, food, pathogens, and insects. In terms of total human microflora, there are orders of magnitude more microbial cells than human cells on the average human. In addition, 99% of terrestrial microorganisms do not grow under laboratory conditions; this was not recognized during the Viking era and has troublesome implications for making full inventories of living contaminants. For Planetary Protection, bacterial endospores such as Bacillus *spp*. are the most worrisome, as they are highly resistant to heat sterilization and can remain dormant for millennia, with the ability to quickly convert back to vegetative cells.

NASA uses a number of internal standards, based on Viking era practices, to determine what type of microorganisms are present on spacecraft components: surface swabs, followed by culture, evaluation and counting (cheap, easy and well-defined). A standard assay involves counting heat-resistant organisms that have grown in 72 hours on a culture medium held at 32°C. Limulus amoebocyte lysate (LAL) and total ATP assays measure cleanliness and bioburden, but do not correlate directly with spore counting. In response to a question on the use of more modern standards, Dr. Conley remarked that she would like NASA to have standards that align more with ISO-level, biological standards. Dr. Lindberg asked why NASA does not employ more standardized methods for all spacecraft going to Mars.

Dr. Conley detailed the Viking life detection experiment, which according to the principal investigator (PI), found life on Mars via a carbon-labeling experiment. Subsequently, this experiment was determined to have failed. Viking's mass spectrometer found only chlorinated methane, which was interpreted to be cleaning fluid. It is critical to gain a better understanding of the implications of false negatives, true negatives, false positives and true positives.

Dr. Gerhard Kminek of the European Space Agency (ESA) presented definitions of planetary protection (PP), the scope of which covers two quite different aspects. The first is the prevention of "forward-contamination" – the carriage of Earth life and inorganic contaminants aboard spacecraft systems bound for solar system bodies that could compromise scientific investigations related to life. PP is not meant to protect extraterrestrial life from a moral or ethical standpoint; it is meant to protect the investment in space science and exploration. The second aspect covers the potential hazard of "backward contamination" – the carriage of life from other solar system bodies to Earth – in line with the precautionary principle of environmental protection.

Concern for PP was first raised in 1958, and was nicely summarized in an article by Joshua Lederberg in the journal *Science*. An *ad hoc* committee, the Committee on

Contamination by Extraterrestrial Exploration (CETEX), was established soon thereafter and developed guidelines, which were subsequently moved to the jurisdiction of the Committee on Space Research (COSPAR). The first space flights to use these guidelines were the 1961 Ranger missions. More detailed, quantitative regulations, particularly for Mars, were adopted by COSPAR in 1964. Today, Article IX of the United Nations Outer Space Treaty continues to provide a framework for PP. The Outer Space Treaty now has 114 signatories, all of which have pledged to avoid harmful contamination (forward contamination) and to avoid adverse changes in the environment of the Earth (backward contamination). COSPAR maintains and promulgates a planetary protection policy for the reference of spacefaring nations, both as an international standard on procedures to avoid organic and biological contamination in space exploration, and to provide accepted guidelines to ensure compliance with the Outer Space Treaty.

PP is evolving as we learn more about life and about conditions in space and the solar system. Updating planetary protection policy is systematic in nature, based on new data or recommendations from advisory groups. A study or a workshop is usually organized to respond to new data, results of which are presented to the COSPAR Planetary Protection Panel. The Panel then makes its recommendation to the COSPAR Bureau and Council, which votes on any changes in policy. This process can take 1-2 years.

Earth-return missions can include human or robotic-based sample return. During the Apollo era, a substantial lunar quarantine program was established based on the advice from the Interagency Committee on Back Contamination (ICBC), which was quickly disbanded after it became clear that the Moon did not pose a hazard to terrestrial organisms. The consistent message from a 2009 National Research Council (NRC) report on sample return from Mars is that such a sample should be considered potentially hazardous until proven otherwise, and thus must either be contained or sterilized. The NRC report also recommended an independent oversight committee for both the planning and implementation phases of a Mars sample-return mission.

Current COSPAR planetary protection principles for human Mars missions are based on the fact that the intent of PP is the same whether the mission is human or robotic. Safeguarding Earth is the highest priority. In the Apollo protocol, the preservation of astronauts' lives took precedence over quarantine; it is not clear that this approach would be acceptable today nor if this would be in line with national and international regulations.. Ms. Gabrynowicz commented that there is also an international treaty on providing assistance to humans in space. Dr. Kminek agreed that while there are guidelines, they are not good enough to develop flight systems. NASA organized a workshop at Ames in March, and COSPAR has undertaken a similar effort, to issue detailed human mission PP requirements over the next two years.

Dr. Conley continued the briefing, touching on the interagency coordination, agreements and communications underlying PP at NASA, including relationships with the State Department, the Centers for Disease Control (CDC), Department of Homeland

Security (DHS), Environmental Protection Agency (EPA), the White House Office of Science and Technology Policy (OSTP), National Science Foundation (NSF), National Institutes of Health (NIH), Federal Aviation Administration (FAA), etc. ESA-NASA cooperation is governed by a formal Letter of Agreement, originally signed in 2007, which enables cooperation and coordination of PP activities. NASA PP policy is governed by NASA Policy Document (NPD) 8020.7G, which states that the PPO acts on behalf of the Science Mission Directorate (SMD) Associate Administrator (AA) to maintain and enforce the policy. NASA obtains recommendations on PP issues from the NRC's Space Studies Board (SSB). Advice on PP is obtained from the NAC Planetary Protection Subcommittee. Specific requirements for robotic missions are codified in NASA Procedural Requirements (NPR) 8020.12D; general guidelines for human missions are contained in NASA Policy Instruction (NPI) 8020.7. NASA PP policy complies with COSPAR policy. NASA supports international missions only if COSPAR policy is followed.

In a brief side discussion about commercial flight, Ms. Gabrynowicz provided some clarification of terms: in Europe, "commercial" means generating revenue and can be governmental. In the US, commercial means private sector, and hence the need for an additional regime to license the private sector. In a recent House of Representatives Bill, no. 1508, no licensing regime is required for commercial exploration of space. This unprecedented bill may become law, and potentially exposes the US to unlimited liability. NASA is not a regulatory agency and cannot influence certain private launches to asteroids or other celestial bodies.

Dr. Conley detailed some features of NPD 8020.7, in which the SMD AA is designated as responsible for overall administration of NASA's PP policy. The PPO role includes prescribing standards, procedures and guidelines applicable to all NASA organizations and programs, and ensuring that all missions are compliant prior to launch. Requirements per 8020.12 state that documentation is not required for some heliocentric or Earth-orbiting missions. Required documents and contents are dependent on the mission category. Additional mission-specific documentation and requirements can be imposed or negotiated during project interactions with the PPO. PP considerations for robotic and human missions including avoiding the contamination of target bodies that could host Earth life; ensuring biohazard containment of samples returned to Earth; and on human missions, monitoring human health status as well as microbial populations over the mission period, to identify any alterations caused by exposure to planetary materials. General requirements for impact avoidance for Mars are also part of the PP regime: the probability of impact should be less than 1×10^{-4} for a period of 50 years. For Europa and Enceladus, the same probability of impact, per mission, is required.

There are five mission categories:
I- not of direct interest for understanding the process of chemical evolution.
II- Of significant interest for understanding chemical evolution but remote change of contamination- documentation required.

III- Of interest to chemical evolution/origin of life which contamination could jeopardize- substantial documentation and mitigation required. Flyby/orbiter mission.
IV- Type III conditions as applied to lander/probe.
V- Earth-return from any Solar System body, further subdivided into "restricted" vs. "unrestricted" conditions.

Missions such as Cassini-Huygens were considered as Category II, because it was not known there might be liquid water in the subsurface of Titan. The Dawn mission at asteroid Ceres is a Category II, as Dawn was designed to not impact Ceres. The Hayabusa comet mission was characterized as Category II on the outbound leg, and Category V Unrestricted Earth Return for the inbound leg.

Category III/IV requirements for icy bodies include bioburden reduction, to reduce the probability of inadvertent contamination of a watery body to 1 in 10,000. The implementation approach for the Juno mission to Jupiter is to reduce the probability of introducing a viable organism to the same probability. Mars sub-categorizations are numerous, and are dependent upon whether the spacecraft is an orbiter, probe, lander, or rover, with differing stipulations for orbit lifetimes, bioburden restrictions, and the possibility of contacting or inducing a Mars Special Region, the latter of which is defined by specific parameters of existing, or induced, water activity and temperature.

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Dr. Lindberg called the meeting to order and Dr. Kaminski made administrative announcements. Dr. Lindberg addressed remarks to the newest members of the subcommittee, describing the unique nature of PPS within the NAC structure. Unlike other subcommittees, PPS advises NASA through the AA of SMD on matters of forward and backward contamination, and thus represents a much wider range of expertise than other the other science subcommittees. Recently PPS has been contemplating PP associated with missions initiated by non-state actors. NASA has no association with these entities unless requested, however NASA remains the most well-informed community with respect to PP. Therefore, Dr. Lindberg averred, PPS must continue to address the shared concerns over the actions of non-state space exploration companies and how they execute their missions, with regard to the U.S. obligations as laid out in the Outer Space Treaty.

Planetary Protection Issues and Updates

Dr. Conley presented the most recent issues of concern to PPS, first reviewing the 2014 NASA Strategic Goals and Objectives document, and the policy documents that govern the implementation of PP policy. PPS provides expert advice to NASA on PP by reviewing mission activities, considering and advising on points of policy, providing guidance on programmatic direction, and serving as a mechanism for interagency coordination within the US government and internationally. The PPS is mentioned in the Code of Federal Regulations, given the importance of avoiding contamination for both scientific and societal reasons.

Recent recommendations of the PPS centered on the continuation of its biannual joint meetings with the ESA Planetary Protection Working Group (PPWG), a 2011 recommendation that was formally accepted by NASA. PPS is pursuing this recommendation. More recently, in late 2012, the PPS issued no formal recommendations, but issued an observation on the Mars Science Laboratory (MSL-Curiosity) Lessons Learned (LL) report. The Mars Exploration Program (MEP) is responding to the PP section of the MSL LL report, and the PPO has been working to incorporate Lessons Learned in an ongoing process. A PPS recommendation from April 2013 stated that mission projects should include the PPO early in mission planning and design; a response to this recommendation is also in process. Of note, the Mars 2020 mission program sent five of its staff to the most recent PP course, as an example of its response to MSL Lessons Learned. Representatives from the Europa team were also attendees at a recent course. In 2014, PPS made several recommendations to improve the communications between the Mars 2020 team and the PPO, and to ensure that some PP input be made to FAA/Department of Transportation (DOT) license applications. Dr. John Rummel commented that ultimately, the State Department is supposed to approve the DOT licensing if it affects international obligations. Dr. Conley noted that interactions are ongoing to better document these practices as per the PPS recommendations. In November 2104, PPS issued observations supporting improvements in communications with the Mars Interior Exploration using Seismic Investigations, Geodesy and Heat Transport (InSIGHT) mission, Mars 2020 and the Human Exploration and Operations Mission Directorate (HEOMD). The subcommittee also raised a concern that the reporting line of the PPO be consistent with its responsibility to assure continued treaty compliance. Dr. Conley noted in fact that good support was in place thus far. Addressing concerns about joint meetings with ESA, she also noted that Dr. Lindberg was able to attend the recent PPWG meeting (April of this year).

Ongoing actions from the PPS include creating an SMD lead for responding to the MSL LL report, which has been initiated. The PPO is also in the process of ensuring appropriate requirements flowdown in its discussions with the Mars 2020 mission, which involves the revision and coordination of PP documentation and expansion of training options. The PPO is also ensuring cross-directorate coordination, and is exploring opportunities with the Safety and Mission Assurance office. Internal SMD activities include upholding the separation of implementation of Planetary Science Division and PPO requirements, and the development of an operating plan.

Planetary missions of recent note include Cassini-Huygens, which is nearing the end of its extended mission, and will undergo reviews to ensure continued compliance. New Horizons is scheduled to fly by Pluto in July; PPO is waiting on written documentation of impact avoidance probability. Juno and the Origins, Spectral Interpretation, Resource Identification, Security, Regolith Explorer (OSIRIS-REx), the latter of which is an asteroid sample-return mission, are also under active monitoring by PPO. The MESSENGER

spacecraft has impacted Mercury as planned; the mission will be reporting to the PPO on the estimated location of impact (disposition of hardware). The lunar mission Gravity Recovery and Interior Laboratory (GRAIL), and Dawn at Ceres, are both complying with PP in terms of orbits (highly unlikely to impact targets). The ESA Trace Gas Orbiter mission to Mars (a life detection mission) includes a NASA-contributed instrument, the Mars Organic Molecular Analyzer (MOMA), the cleanest instrument NASA has produced since the Viking era. The PSD 2012 Discovery selection to Mars, InSIGHT, is a Category IVa mission. To retain this category, the mission must demonstrate that the probe will not contact Special Regions. InSIGHT will land at Elysium Planitia, a dry, unconsolidated regolith region, where it will insert a mole to measure the thermal properties of Mars subsurface. The mole is required to not penetrate beyond 5 m of surface. On the basis of these observations, the mission has complied with its categorization thus far. 'The addition of the MarCo cubesats as a secondary payload on the InSight mission raises concerns about ensuring that planetary protection compliance is not jeopardized for any of the spaceflight hardware. On the MSL-Curiosity mission, there have been reports of methane, and suggestions of possible contact with recurring slope lineae (RSLs), both of which are affecting plans for the future traverse of the rover. Mars 2020 is maintaining its ongoing communication with the PPO. The strategy for designing its caching sample technique is still under way, as the mission goes about identifying different payloads and assigning temporary categories as various subsystems are identified. Sample return requires that Category V restrictions be followed. According to Dr. Conley, as concepts evolve for sampling, PP implementation strategies will change as well.

Planetary protection for human missions is informed by COSPAR guidelines on Mars, and must include protecting the Earth and avoiding harmful contamination of solar system body targets. There will need to be a different implementation strategy for human missions, but the planetary protection goals are the same. PP in the context of human exploration is early in its conceptualization; further research will reveal more information on which a future implementation strategy can be based.

In response to PPS observations, PPO has increased staffing with the recent hiring of Drs. Pugel, Errigo, and Novo-Gradac; is carrying out frequent interactions with the SMD AA; and has realized some increases in the budget for research proposals.

Planetary Protection Knowledge Gaps Workshop

Dr. Bette Siegel, Executive Secretary of the NAC Human Exploration and Operations Committee, presented results from a workshop held at Ames Research Center in March 2015. The workshop had 85 attendees, with representation from industry, academia, CDC, and one or two international groups. The workshop was divided into three breakout sessions: microbial and human health monitoring; technology and operations for contamination control; natural transport of contamination on Mars. The original purpose of the workshop had been to develop an NPR, but an NPI was drafted instead, as a preliminary step toward an NPR that would eventually codify design requirements for human exploration missions.

The workshop held discussions on the information needed to develop a full NPR for Planetary Protection on human missions; to assess the types and levels of research needed; and to build a network of expertise. Overall, the goal was to raise awareness of the need for PP for human-rated missions. Each group focused on five questions in seeking both the state of knowledge and the knowledge gaps in PP, including what sort of research and development (R&D) is critical for each study area, and special information for dealing with nominal vs. off-nominal events. Dr. Rummel commented that the subjects of life support systems and extravehicular activity (EVA) in particular were of great importance.

Outcomes to date have led to tasks such as EVA swab testing on the International Space Station (ISS). Arctic field tests for mini-DNA sequencing units are anticipated for summer 2015, to demonstrate low-cost DNA sequencing for potential use on ISS and in space exploration. Four papers are due to be published in *Advances in Space Research*: a literature review on Planetary Protection and human missions; a summary of the Strategic Knowledge Gap (SKG) workshop; and an overview of Systems Engineering and Planetary Protection in relation to future human exploration; and environmental aspects.

The workshop entailed 2.5 days of detailed information sessions, with the last day devoted to summarizing aspects of the breakout sessions. A total of 15 SKG areas were considered, including space power and energy storage, thermal management systems, and human exploration destination systems. Dr. Rummel noted that engineering issues related to dust control also feed into PP contamination concerns. Ms. Siegel summarized by emphasizing the importance of keeping the ball rolling, and she remarked that the AAs of both SMD and HEOMD have been very supportive of the effort. Dr. Boston recommended that the workshop results be made available to the gravitational and space biology communities. A workshop report and several other papers are being prepared for publication.

Planetary Science Division Update

Dr. James Green, Director of PSD, reviewed the latest division activities. The Europa mission is moving to Key Decision Point (KDP)-A this month. The MESSENGER mission terminated in April; the Mars Atmosphere and Volatile EvolutioN (MAVEN) spacecraft is in orbit around Mars, taking measurements of Mars atmospheric parameters. Observations of Siding Spring, a 500-meter Oort cloud comet, were made by all Mars assets in October 2014. The Curiosity rover is currently exploring Mt. Sharp. Among the international missions, the Rosetta spacecraft made a spectacularly successful landing; and NASA will be supporting the Hayabusa-2 sample return mission with the provision of some instruments, as well as with the Deep Space Network (DSN).

New Horizons is preparing to fly through the Pluto system in July. Plans are on track for a Discovery 2014 step-1 proposal selection in September. NASA plans some involvement

in the upcoming attempt to place the JAXA Akatsuki spacecraft back into orbit around Venus. The ESA BepiColombo launch has been moved to 2017. The Mars mission, InSIGHT, will be launching in March 2016, followed by the launch of OSIRIS-REx soon afterward. The MESSENGER mission came to an end after having observed the planet over 8 Mercury days (1504 Earth days), and the plan to impact spacecraft went smoothly on 30 April. It is believed that the spacecraft impacted "behind" the planet; its location is believed to be near 54.4° latitude, 210.1° longitude. MESSENGER studied aspects of the solar wind, magnetosphere reconnection, and the dynamic magnetosphere of the planet, and found Mercury's dipole to be tipped up by as much as 20 degrees. The planet is seen to be shrinking. The spacecraft imaged some polar deposits, thought to be water in permanently shadowed craters. Mercury's volatile richness is roughly equivalent to that of Mars. Principal Investigator Sean Solomon will give a seminar at NASA Headquarters on 2 July.

Dawn continues to observe Ceres, after having approached the asteroid at about 60 miles/hour, much more slowly than in other orbital missions. Observations thus far include older cratered terrain and areas of basins with few craters, inferred to be younger regions. The spacecraft is being positioned to better observe the various bright spots seen in some craters. Herschel Space Observatory has previously observed water vapor at Ceres. There is much speculation: the spots could be salts, or a cryovolcano. Dawn is now in a 4900-km survey orbit, and will be there for 22 days, after which it will descend to 850 km, then 476 km. It will stay at a low altitude for a significant period of the 406-day primary mission. Instruments on board, in addition to visible wavelength cameras, there are infrared cameras that will be able to extract some mineralogy.

New Horizons has already characterized new moons around Pluto; in addition to Charon, there are now Styx, Nix, Kerberos and Hydra. The presence of these moons will complicate the fly-by somewhat. Only one-third of Pluto's orbit around the Sun has been observed; it will be necessary to take frequent optical navigational images to determine the placements of Pluto and Charon. There may well be more moons around Pluto that have not yet been seen. The known smaller moons are 12-15 km in diameter. A grain of dust could potentially destroy the spacecraft, so hazard avoidance is critical. It takes 4.5 hours to transmit data, a 9-hour round trip. The hope is that Charon will have swept out any dust as the spacecraft moves through the system. After New Horizons passes Pluto, it will look back and evaluate its atmosphere by occultation. The final image resolution will be 3.9 km per pixel. The fly-by will be on autopilot while the scanning of Pluto is under way.

In response to a question about radioisotope powered generators (RPGs), Dr. Green replied that one is ready to go for the Mars 2020 mission. Within a few years, it is anticipated that there will be sufficient plutonium for missions throughout the 2020s. New Horizons will move into the Kuiper Belt to study Kuiper Belt Objects (KBOs), which number 1500-1600 thus far. The Hubble Space Telescope (HST) has identified two

potential targets for New Horizons to visit, should it be selected for an extended mission.

The latest Discovery proposals ($450M cost cap, excluding launch vehicle and phase E – operations) are now in and are being evaluated for selection in September 2015. Discovery missions currently in development include an instrument for BepiColombo, and Mars InSIGHT (Vandenberg Air Force Base launch). The next New Frontiers mission is Juno at Jupiter, launched in August 2011, followed by Osiris-Rex, launching in 2016. OSIRIS-REx will visit the asteroid Bennu for 400 days, collect a sample and return it to Earth. The next New Frontiers Announcement of Opportunity (AO) will be released at the end of FY 2016. The New Frontiers #4 AO contains a comet surface sample-return mission, lunar south pole Aitken basin explorer, Trojan tour and rendezvous mission, Saturn probes, and a Venus in-situ explorer. New Frontiers call #5 includes an Io observer and a lunar geophysical network mission.

The Europa mission under development continues to make progress. Its principal goal is to explore the habitability of Europa in a high-radiation environment. Instruments will include a neutral mass spectrometer, magnetometer, and ice-penetrating radar. Like Cassini, the Europa Clipper mission concept uses multiple fly-bys: a total of 45 low-altitude fly-bys with the lowest being 25 km, with the majority flown below 100 km to obtain global regional coverage. It was necessary to trade large amounts of fuel for shielding (which also increased spacecraft lifetime from months to years); the mission also plans to use a simpler operations strategy with no need for a real-time downlink. The mission currently has good margins on both technology and mass, while efforts continue to confirm the existence of plumes on Europa, previously observed by HST. The current thought is that the end-of-mission scenario will be an impact on Ganymede.

Mars Exploration Program Update

Dr. James Watzin, Program Director for the Mars Exploration Program (MEP), provided a briefing. The MAVEN aeronomy mission is six months into its operations; while the Mars Reconnaissance Orbiter (MRO) HiRise camera continues to function well, having recently found the Beagle-2 lander. Opportunity, at 11 years, 2 months of age, continues to function and provide ground truth data for remote sensing assets. There have been some issues with MRO's flash memory unit, which are attributed to aging. Curiosity is currently exploring Gale crater's Mount Sharp. MEP is healthy and improving. Operational assets are returning remarkable science, despite being a decade old. The Mars 2020 mission is proceeding well; and the MOMA-Mass Spectrometer instrument contribution to the ESA Exo-Mars mission is now in fabrication and assembly.

Much attention is being directed to future mission planning, working toward the ultimate goal of sample return from Mars. There is also a strong interest across the Agency in human exploration at Mars. It is clear that it is time, however, to begin to replenish orbital assets at Mars to support future operations for sample return.

Therefore the next Mars mission likely to be an orbiter, followed by an ascent vehicle that will bring the sample to an orbiting asset. MAVEN does carry a communications package, lending confidence to support for the Mars 2020 rover. The ISRO orbiter that is now at Mars does not have a communications asset. The 2016 ExoMars will have an Electra box for transmit/receive capabilities.

MEP is moving into the habitability phase, or looking for ancient life. At present, MEP has no missions planned for after 2020. The Mars 2020 baseline mission builds on the Curiosity mission, investigating sites for biosignatures and sampling, after which it will seal up a sample for retrieval by a future asset. Mars 2020 is now in phase B and scheduled for a Preliminary Design Review (PDR) at the end of this calendar year. MEP is pleased with the positive Standing Review Board (SRB) findings on mission maturity and high-heritage approach, which allows the focus of attention on newer aspects such as the cache system. The project has published an Environmental Impact Statement (EIS) for its radioisotope power unit, designed to provide about 100 W of continuous power production that degrades over time. Payload agreements are being finalized. Spain is providing a high-gain antenna to the mission. An infinite focus fine-scale imager has been added to the payload, as well as some components for the Entry, Descent and Landing (EDL) system to improve imaging. The sampling strategy is still in process. An adaptive cache approach is being considered; i.e. deposit samples on the surface in a to-be-determined operational construct, to be put in a container that will be provided at a later time. Dr. Lindberg noted that control samples would have to experience the same environment as the science samples; Dr. Watzin responded that an adaptive strategy allows for controls to be treated as required. Dr. Peter Doran commented that samples should be wrapped carefully, and put in a lightweight bag, perhaps. Dr. Watzin recognized that the container is another failure point/bottleneck, which will bring many attributes that will need to be mitigated; space on the rover is also limited. Dr. Colleen Cavanaugh noted that the science value of the sample is paramount, and that contamination must be carefully considered. Dr. Watzin averred that samples would be sealed, which is how the protection is conveyed, and emphasized that the science team is very much involved in the trade studies, and thus far have been proponents of the adaptive caching approach.

Dr. Lindberg asked how the mission planned to “break the chain” of contact in sample return. Dr. Watzin replied that this would likely take place in Mars orbit, and perhaps one more time in the Earth environment. Dr. Lindberg asked if anything were built into caching system to reflect the breaking of the chain. Dr. Watzin responded that the sample could be contained in a tube, and within a Mars Ascent Vehicle (MAV), or an orbital element that will transport sample back to Earth. These concepts are still in development. A representative from the Jet Propulsion Laboratory (JPL) commented that whether the samples are bundled or singly- they still will have Martian material covering them and will still have to be contained, perhaps requiring a double-wall caching system. Dr. Rummel noted that there are actually two chains to break for Mars

2020; first, we don't want to bring Martian materials home, and secondly, there will be Earth-associated bacteria on the rover that should not get into the sample.

Dr. Watzin reported that the MOMA-MS instrument development is progressing smoothly. A qualification simulator model is on track for delivery by the August 2015 deadline, and first spectra has been obtained from the flight model. ExoMars underwent a System Delta PDR in Russia. The French (CNES) contribution of a MOMA-Gas Chromatograph has been delayed due to lack of funds.

MAVEN has been making interesting observations, such as the presence of high- altitude dust clouds near the terminator, ultraviolet aurorae, and ion exchange behavior in the atmosphere. MRO and Mars Express continue to expand the understanding of carbon dioxide at Mars. MRO has found evidence of clay minerals that lubricate landslides. Curiosity has found methane spikes that could be either geological or biological in origin. Dr. Lindberg commented that either of these findings has implications for PP; the production of methane requires water in contact with minerals at temperatures that would be indicative of Special Regions.. Asked what the sense of science was with respect to Gale Crater harboring special regions, Dr. Watzin reported that data was not conclusive. Dr. Mitch Schulte noted that most of the rocks in Gale Crater seem sedimentary, and it is unclear where the methane is coming from, unless it is stored as clathrate. Dr. Rummel added that the isotopic signature of methane over time would be much more informative, but that thus far, there has been no signature of surface water. More worrisome would be salts associated with flow features, which might result in a salt crust, which should not be in contact with thermal units on probes or landers. Dr. Watzin agreed that there are still critical SKGs to be answered on environment, resources and evidence for habitability. Dr. Rummel commented that there is snowfall on Mars, as seen by the lidar on the Phoenix lander, which should also be considered as a potential *in situ* resource.

Dr. Watzin portrayed MEP as being in a transitional decade, and enumerated some science activities that will help prepare for the future, including revision of the MEP Analysis Group (AG) goals document, preparing for next Decadal Survey, and continuing dialogue with HEOMD. A Next Orbiter Science Analysis Group (SAG) and Human Science Objectives SAG have been created, and progress is being made on landing site observations. The second Landing Site Workshop will be held the first week of August 2015. A Human Landing Site Study is ongoing, as well as In Situ Resource Utilization (ISRU) and Civil Engineering Working Groups.

Dr. Boston commented that it is difficult to incorporate new discoveries into the Decadal Survey framework with no clear guidance at present for missions to Mars beyond 2020. Dr. Watzin felt that the Decadal Survey guidance clearly stated the importance of getting a sample back to Earth, and NASA is going down the path to do just that. Mars planning can remain consistent with themes even in advance of the next survey. There is some future planning MEP activity that will be inserted into the,

Planning Programming, Budgeting and Execution (PPBE) process, trying to get to the landed element of the mission. Dr. Steneck asked if there were any other benefits to be gleaned from ongoing positive collaborations. Dr. Watzin felt that the ability to execute a round trip to Mars is a huge theme that would excite a large segment of both the community and the general public. Dr. Jon Miller commented that an NRC report on Human Space Flight raised questions on just how much public support there would be for such a mission, as well as technical questions on the feasibility of a two-way trip. Dr. Watzin felt the key was to get there a step at a time. If sample return can be carried out, it is a smaller scale experiment than that required for a human-rated mission, and as such can help build confidence in other aspects of the architecture.

Discussion

Dr. Lindberg queried members on issues for the table. Responses included:

- Dr. Rummel- breaking the chain between Mars and Earth in both directions; timeframe (earliest chance to return a sample is in 2029).
- Dr. Lindberg- concerned about terrestrial contamination on the outbound leg. Adaptive caching may result in a pristine sample that is contaminated on outside. How can the sample be safely extracted from its carrying container?
- Dr. Kminek- architecture is a chief concern. The intention seems to be to break the chain in orbit. It might be useful to have an iMars Phase 2 report presentation at the next meeting to give an idea of what an architecture might look like after the Mars 2020 mission.
- Dr. Goreva-what is the condition of the capsules before sample collection, during, and after?
- Dr. Cavanaugh- cross-contamination of samples, as well as time elapsed between sample caching and return to Earth.
- Dr. Miller- if you find microbes below surface that have been shielded from radiation, what happens when they come above the surface?
- Dr. Kminek- because the Curiosity landing site is more interesting than originally thought, there might be a time where operations and PP should have a closer interface during ongoing and future Mars missions. PPS should ask Mars 2020 how they handle communications with the PPO.
- Dr. Rummel- disposal of the Europa spacecraft.
- Dr. Goeres- a control design for sample return.
- Dr. Boston- does the presence of water vapor on Ceres raise the body to the level of PP concern? A longer-term issue is that there may be vapor or fluid-phase water on small bodies throughout the Solar System.

Mars InSIGHT mission

Drs. Joel Krajewski and Andy Klesh presented a briefing on Mars Cube One (MarCO), two nanosatellites the size of a cereal box, which will be launched along with InSIGHT to support EDL. The two MarCO spacecraft will launch with the InSIGHT spacecraft and deploy right after separation, and will fly by Mars while InSIGHT descends. MarCO will

provide an 8kb/s link, collecting data on a UHF antenna and relaying it to Earth on X-band. The spacecraft use a cold gas system for trajectory correction and maneuvers. Solar arrays are the primary power source. The cubesats will sit outside the fairing of the InSIGHT spacecraft.

MarCO submitted its PP plan to the PPO on 7 June, complying with a Category III classification as required by NPR 8020.12D. The project is taking special considerations with the propellant system. The baseline PP plan is impact avoidance, for which analyses have been completed. The contingency plan is burn-up and break-up; the current trajectory analysis indicates that this backup will not be required. The trajectory beyond fly-by is heliocentric. The cold gas system is comprised of a tank where all valves and pieces are held within the tank itself. The holding tank is kept at lower than 50 degrees C; the tank has been tested at a range between -30°C and 70°C. Asked about the two-step "snap roll" maneuver performed by the Centaur vehicle, Dr. Klesh explained that it is the same as a typical "CCAM" maneuver; Dr. Conley noted that the speed and two stages of the snap roll should be part of the PP analysis.

Dr. Jason Willis presented an update on the InSIGHT mission, a Category IIa mission that is based on Phoenix heritage, and is carrying an updated science payload with a seismometer and penetrometer "mole." These instruments are Seismic Experiment for Interior Structure (SEIS), provided by France, and Heat Flow and Physical Properties Package (HP3), a contribution from Germany. The mission has a March 2016 launch window, and will be the first planetary launch out of Vandenberg Air Force Base (VAFB). InSIGHT will fly on an Atlas V-401 launch vehicle and arrive at Mars in September 2016, and will use a direct-to-Earth (DTE) UHF link as well as a communication link with MRO. The cruise period is 6.5 months, and the EDL technique is essentially that used for Phoenix. The payload also includes three additional instruments: Rotation and Interior Structure Experiment (RISE), which uses X-band radio, Instrument Deployment System (IDS), and Auxiliary Payload Sensor Suite (APSS).

Surface deployment will take place over 67 sols, with no strict time constraint for deployment. There will be one full year of science monitoring, with only a minimal support team needed during science operations. Technical margins for operations are adequate. Landing site constraints are needed for the solar power margins; one prime candidate has been narrowed to an etched -terrain site called Elysium Planitia, which is close to the Curiosity site and may therefore compete with the UHF band. The mission will use the same strategy that the Phoenix and Mars Exploration Rover (MER) missions used for the treatment of error ellipses.

InSIGHT is designated as a PP Category IVa and has been designed to comply with bioburden requirements. The mole will not descend further than 5 meters below the surface, does not have an internal power source, and will not generate a thin liquid film that can transport a 50 nm particle. Currently the mission is compliant with all bioburden requirements. One hundred-thirty sampling events have been performed,

with 952 swabs and more than 12,000 petri dishes. The project is currently focusing on PP, and is planning a dedicated lab at VAFB to support space and launch vehicle operations. Instrument deliveries are planned for late July to begin the integration process. A PP Landing Site Review is scheduled for October 2015, and a Flight Readiness Review for February 2016, in preparation for launch on March 4, 2016. Drs. Conley and Lindberg commended Dr. Willis and his team for their "trailblazing" PP efforts. Dr. Conley noted that while a review of probability of impact had taken place for InSIGHT, the MarCO mission, which is regarded as a subsystem of InSIGHT, has not yet provided this information. Dr. Lindberg commented that it sounded like the process was analogous to upper stage analyses. Asked if bioburden testing includes samples for molecular analyses, Dr. Conley replied that this is not done for the outbound spacecraft. For inbound components, however, Mars 2020 is considering molecular analyses. There are no direct comparisons between culture-based vs. molecular analyses as yet, as biochemical assay don't distinguish between live vs. dead microorganisms. Dr. Kminek noted that there are data on such comparisons, and that is also worthwhile to collect type of microbes, as recommended by ESA PP. COSPAR also requests that such types should be identified. Dr. Onstott commented that microbial characterization really needs to be expanded for Mars 2020. Dr. Conley agreed. Dr. Boston pointed out that in the Special Regions on Mars-SAG, there has been much discussion about the value of cleanroom and spacecraft inventories. The rare life issue is out there, so missions need to do both cultures and molecular assays to detect it. Dr. Onstott recommended a serious discussion on the utility of the latest molecular assays vs. current NASA standards.

<u>NRC Report on Sample Contamination for Mars Sample Return</u>

Dr. Conley presented results of a series of meetings that considered the risk of terrestrial contamination during a Mars Sample Return mission. International agreements on planetary contamination and protection date back to the Outer Space Treaty OST of 1967, and are encoded in Article IX of the Treaty. COSPAR maintains the international consensus standard PP policy for supporting compliance with the Treaty. The current policy was approved by the COSPAR Bureau and the Council at the COSPAR Assembly in 2011. In the context of restricted-Earth return, Category V, many studies have led to the publication of both a Draft Test Protocol and of requirements that ESA and NASA are working to refine. The NRC recommends that no uncontained Mars material should be returned to Earth unless sterilized, while the European Science Foundation (ESF) recommends that the probability of release of a Mars particle shall be less than one in a million. The size of the particle, based on the observations of terrestrial microbial life, is restricted to no larger than 10 nm.

NASA policy states that for restricted-Earth return missions, there is an extensive set of additional documentation, associated activities and reviews that are intended to assure that Earth's biosphere is not adversely affected by the introduction of material from returned samples. An Earth Safety Analysis Plan (ESAP) is the primary planning document covering the Earth-return phase of the mission. NASA requirements for Mars

Sample return are as follows: samples are treated as hazardous until proven otherwise; unless specifically exempted, the outbound leg of the mission meets category IVb requirements; a Sample Receiving Facility (SRF) shall employ certified personnel and instrumentation to perform the battery of tests described in the NASA life detection and biohazard protocol; and an independent science and technical advisory committee shall be constituted with oversight responsibilities for sample materials returned from Mars. Certification details have yet to be decided for "certified" personnel.

At two meetings of subject matter experts, in May of 2014 and 2015, discussions of various aspects of contamination, curation, science and engineering, and oversight took place, but resulted in no consensus opinion. What is clear, however, is that returned samples must be differentiated as to whether the measurements indicate organic contamination or life detection. Dr. Doran commented that it is almost certainly the case that a false negative result will be returned from Mars, given the sample lingering for 20 years on the irradiated Mars surface. Dr. Conley noted that NASA policy covers precursors, remnants, and life forms. Dr. Goeres suggested the possibility that Mars life forms may well have evolved to adapt to radiation.

Dr. Boston commented that the overall feeling from the two meetings of experts was that the conjoined paranoia in thinking through both problems suggests that every mission ought to have a PP and a contamination systems engineering expert. Specific issues exist with Mars 2020 planning, particularly with respect to cleaning processes, the nature of the sample containers, circum-spacecraft recontamination potential, and how to deal with the contamination of the outside of the sample container. Dr. Kminek noted that there was an Organic Contamination Panel (OCP) minority opinion, and asked how this was handled. Dr. Boston reported that there had been disagreements about quantities associated with organics contamination. Tolerances and standards for sterilization were all over the place, and there seemed to be a major set of conceptual flaws. There was no clear indication of how sample caps would be treated, for instance. A Mars 2020 project member responded to this discussion and described the process of testing and validating the sample containment tubes being designed for Mars 2020. Dr. Rummel raised issues about contamination regarding the MOXIE (oxygen-generating) instrument, as well as the single source of contamination being the rover itself; that kind of contamination control is not being looked at for Mars 2020. The team member allowed that this type of contamination control is recognized by the mission, and that it is being considered in the design. Dr. Kminek noted that the aeroshell and everything in it will outgas during cruise phase, and repressurization will fill all the cavities and could be a major source of contamination for the drill and instruments mounted on the drill. Dr. Rummel added that modeling and experimentation must be done before PDR, which will necessitate multiple potential solutions to treat a complex problem in a complicated system. Dr. Conley suggested that the PPS consider making a recommendation after hearing the results of the two meetings of experts.. Dr. Lindberg suggested that the PPS's next meeting include a briefing on the majority and minority reports coming from the meetings of experts.

NASA Communications Campaign Overview

Mr. Dan Woodard presented a briefing on the NASA Office of Communications. NASA is currently moving from the Shuttle era to ISS, robotic and human exploration of Mars, and is therefore changing its operational model and fostering integration. NASA has an "embarrassment of riches," thus NASA is moving to a more strategic and thematic approach to communication. These themes are Earth Right Now, ISS, Mars, Aeronautics, Technology, Solar System and Beyond, and are currently represented in social media with hashtags. The themes contain rich content with opportunities for integration across priorities. NASA holds a monthly Communication Coordinating Council meeting that deliberates around the communication themes, but which currently does not receive advice outside NASA. The Council has presented the model to the NAC, however, and has received feedback. Dr. Miller commented that a recent NRC report on human space flight shows a steady decline of public support for human space exploration, and asked what the Communications Office was doing to make a difference. Mr. Woodard replied that there is a much more concerted effort within the institutional portion of NASA, and time will tell as to the efficacy of the new communications model. The content itself is compelling; if it's served up the right way, it may improve public engagement. Dr. Rummel observed that success in communicating NASA's message does not preclude a decline in public interest. Dr. Miller commented that while information has moved from a warehouse model to a just-in-time model, the NASA communications program still looks like the 1970s; NASA must adjust to people getting information on their phones and iPads. Dr. Michelle Thaller, representing the Solar System and Beyond theme, pointed out that NASA's visualization application is one of the top three apps for iPhones and iPads. NASA has Space Act agreements with Google that have resulted in the best "citizen science apps," bar none. NASA has been trying to address the compartmentalization issue, and has done so successfully. Mr. Woodard added NASA has been using social media effectively, garnering 300,000 visits per day on its website and 10 million "likes" on Facebook.

Communications also involves a discussion of risk and perceived risk, in that risks perceived to be voluntary are more acceptable than risks perceived as being imposed. Communication can fail when the psychological basis of risk perception is not taken into account. NASA recognizes that public engagement and collaboration will be extraordinarily important in managing the perception of risk associated with Planetary Protection issues. COSPAR recognizes this as well. The Office of Communications is anxious to work with the PPO on these issues.

In response to a question, Mr. Woodard described the process by which press releases are approved: releases involve the technical, public affairs, and communications offices in a tight loop that has not changed appreciably over the years. Dr. Steneck recommended that the ethics of bringing back samples from Mars should be an ongoing concern for Communications. Subcommittee members agreed that the ethics of sample return should be revisited regularly with the stakeholders.

Public comment period

Mr. Daniel Peters from New York Skies asked whether proposed drilling on the moon, 200 m below the surface, raised any concerns for Planetary Protection. Dr. Conley noted that there are no PP proscriptions against lunar operations, per current policy. Lunar missions are Planetary Protection Category II.

Discussion

Dr. Lindberg aired topics for observations or findings. Items for future meetings, in addition to a detailed look at the Mars 2020 caching system, include an outbrief on ROSES 2014 selections; and outbrief on the latest iMars report; and consideration of a joint meeting between PPS and the Planetary Science Subcommittee (PSS). Additional topics suggested: putting aside regular meeting time to discuss specific science topics and the latest discoveries relevant to PP; a joint meeting with the Curation and Analysis Planning Team on Extraterrestrial Materials (CAPTEM); a briefing on spacecraft cleanliness and Mars Special Regions, as well as the role of non-state actors in space; and technical planning in robotics operation (re: Curiosity), instead of learning about PP issues after the fact. Dr. Lindberg agreed with the lattermost statement, noting that Curiosity had missed an opportunity to perform isotope characterization when the methane spikes occurred.

June 10, 2015

Ethics Briefing

PPS members received their annual ethics briefing.

Introduction

Dr. Lindberg opened the meeting, followed by administrative comments delivered by Dr. Kaminski. Dr. Lindberg reviewed the previous day's discussion, reiterating the top discussion topics: the status of current science yielded by Curiosity, and the responsibility of the MSL program team to continue to comply with PP requirements in light of new information gathered during operations. Also, he highlighted the need for PPS to consider the preparation of samples for the Mars 2020 mission.

ESA Planetary Protection/ COSPAR Update

Dr. Kminek, Chair of the COSPAR Panel on Planetary Protection (PPP), presented an update on COSPAR PP. Last March, the program committee held meetings in advance of the scientific assembly to be held in Turkey next summer. The Panel proposed three PPP sessions, all of which were endorsed by the COSPAR meeting committee. These will be three half-day sessions, focused on policy and implementation, mission implementation, and research and development (R&D) for PP. In addition, there will be a joint session with Scientific Commissions B (planets and moons) and F (life science). The session will focus on PP for icy body sample returns. Organizers have confirmed participation in all of the sessions. The committee is also preparing for the second COSPAR Symposium,

usually held in between assemblies; the symposium will take place this year in Brazil. The symposium will include an Interdisciplinary Scientific Lecture "Planetary Protection for Water Worlds," to be delivered by Dr. Rummel.

During the last Scientific Assembly in Moscow, two COSPAR colloquia were proposed, one to prepare an update of the Planetary Protection Policy for Mars Special Regions, and the second to prepare a white paper on sample return from icy bodies. The colloquia will be supported by the International Space Science Institute in Bern, Switzerland, 22-24 September 2015. A list of participants is being prepared. Dr. Kminek invited PPS to nominate representatives to attend.

A COSPAR Workshop on Refining Planetary Protection Requirements for Human Missions, is planned for early 2016 at NASA Kennedy Space Center.

A special issue of *Advances in Space Research* will be released on the topic of "new challenges for planetary protection." The deadline for submissions has been extended to the end of August 2015.

Pertinent panel issues include an update of PP requirements for Mars special regions, human missions, and sample return from Outer Planet satellites. Japan has agreed to participate in the panel, and a JAXA employee was nominated as another Deputy Panel Chair. Russia has also been invited to join the Scientific Organizing Committee (confirmed), and there is continued effort under way to get China and India on board for Panel activities.

COSPAR continues to reach out to communicate the importance of PP. The next step is to publish the current PP policy in the COSPAR Information Bulletin in August 2015. Efforts are under way to simplify the process for submitting relevant post-launch information, through provision of a template document. The COSPAR PPP also hopes to hold PP courses in China and India over the next two years, and is communicating with Mars One and the United Arab Emirates, the latter of which has established a national space agency and is planning a robotic mission to Mars. UAE is a signatory to the Space Treaty. Dr. Lindberg mentioned that MarsOne intends to move its operations from the Netherlands to the US, and is planning a human mission. Mr. Kelvin Coleman, a PPS member representing the FAA, clarified that there is current moratorium on any FAA regulatory action dealing with human space flight occupant safety, which will has been extended through 2015. The FAA has been seeing activities that it doesn't have the legal bandwidth to cover, and is trying to work out a solution with Congressional participation.

Dr. Kminek moved on to cover ESA activities. ExoMars is currently preparing for the Trace Gas Orbiter/Schiaparelli (EDM) launch in 2016. The orbiter is about a ton heavier than MRO, and will be launched by ESA in cooperation with Roscosmos at Baikonur, on the upper stage of a Proton launch vehicle. The Trace Gas Orbiter is classified as

Category III. The spacecraft will undergo a year-long aerobraking phase, then move into a circular, 400-km orbit. An Entry, Descent and Landing Demonstrator Module (EDM), will be released and land close to the MER Opportunity rover site, thus it will have some ground truth with which to compare its data. No special regions will be contacted, and no radioisotopic heat or power sources will be used on the EDM. The mission has completed PP characterization of the landing site, as well as a Critical Design Review (CDR). The spacecraft will be shipped to the launch site in October 2015, where ESA will be bringing its own microbiological laboratory, to check systems before launch.

The ExoMars 2018 mission will also use the Baikonur launch site, and will be comprised of a carrier/cruise stage that will transport a descent model, which contains a rover. Roscosmos is providing radioisotope heater units (RHUs) for the system. ExoMars 2018 is classified as Category IVb, as it is a life-seeking mission. ESA will build the carrier stage, rover, a two-stage parachute, and a drill that will descend 2 meters below the surface to extract cores. The drill has been tested in vacuum and at low temperatures. The landing site selection process is considering four sites; there will be a meeting in October of this year to narrow the selections to two. The ExoMars drill will utilize heritage from the Rosetta mission, and will carry RHUs on the rover and the lander. The parachute is a new development, but it will have some heritage from the ExoMars 2016 mission.

Solar Orbiter will launch at KSC, with NASA providing an Atlas V vehicle. The mission will use a Venus Gravity Assist and is classified as a Category II mission. The upper stage meets the criteria to avoid impact on Mars for 50 years; all other PP analyses and PP plans have been approved. The JUICE mission to the Jovian system is scheduled to launch in June 2022, and will visit Callisto, Ganymede and Europa. The mission is Category III due to planned Europa encounters, but will spend more time investigating Ganymede/Callisto. There will be only two fly-bys, avoiding impact on Europa. The final disposition is planned impact on Ganymede. ESA is developing a new micrometeorite and dust model for Jovian system, and is currently selecting a prime contractor in preparation for phase C/D.

In light of biosafety issues and protocols (e.g., recent anthrax issues at the CDC attributed to failure to sterilize), the community is thinking about re-evaluating protocols for sterilization. Dr. Conley noted that each NASA project monitors bioburden regularly and reports out results. The PPO has an independent monitoring/audit function and does additional assays to independently confirm project results. Dr. Kminek added that when new sterilization processes are introduced, ESA and NASA cross-validate results, and has done this twice with dry heat sterilization and hydrogen peroxide, using multiple indicators. Dr. Lindberg suggested that it might be helpful for NASA to develop standards as a US-wide standard, in conjunction with an independent standards organization (ISO-type). Dr. Conley agreed, noting that ESA uses European Cooperation for Space Standardization standards.

PPS/ESA Planetary Protection Working Group Joint Meeting Discussion

Dr. Lindberg briefly described the ESA Planetary Protection Working Group (PPWG) meeting of April 2015, which he attended as sole representative for PPS. He still hoped to stand up a full joint meeting between PPS and PPWG in October 28-29, 2015, in Madrid. Dr. Kaminski commented that the Science Mission Directorate (SMD) Deputy Associate Administrator Geoff Yoder is supportive of this effort.

Science from Curiosity has raised concerns about possible contact with special regions on Mars. Dr. Conley commented that from her perspective, there is no conclusive evidence of special regions at Gale Crater, although it does appear wetter than previously understood, and the microenvironment has not been well characterized. The open questions argue for more visibility into what the Curiosity team is observing on an operational level. There need to be agreed-upon practices in place, such as identifying trigger points for consulting the PPO. Dr. Boston observed that the formation of special regions is not well understood and constitutes a large SKG, and felt that the conditions at Gale Crater are of concern. Dr. Rummel commented that direct water sublimation at Mars is by no means guaranteed, and is not just of passing interest, as it will be relevant for future human missions. Dr. Kminek felt that a check-list approach would be insufficient; the more critical thing is what the mission should do next. Ceasing operations for several weeks is usually not an option. Should there be a fast-response team between the project and the PPO? What's the trigger? Who decides? Dr. Rummel thought the science team observations should be first-line, but that the Program Manager should make the decision to call in additional expertise. It isn't certain that PPS can do much more than recommend a rigorous system be put in place to sound alarms about planetary protection. Perhaps some science team members could be deputized to do this. Dr. Conley mentioned that there are now proposals in place to visit dark streaks. Dr. Doran proposed a conference call with PPS for each instance.

Dr. Steneck observed that the discussion fits in as a human protection issue, as it entails a protocol, definitions of adverse events, and identifying responses to adverse events. Dr. Goeres suggested that Good Laboratory Practice (GLP) standards could be very helpful with quality assurance and control; an officer with these skills could monitor MSL operations. Superfund sites use these GLP measurements as a matter of course.

Discussion with SMD Deputy Associate Administrator

Mr. Geoff Yoder, SMD Deputy Associate Administrator, held an informal discussion with the PPS. Dr. Lindberg apprised him of the issues before the subcommittee, first raising the issue of the opportunity to meet jointly with the PPWG. He then addressed the concern with ongoing PP activities associated with surface operations at Mars, as well as processes in place for operational response to new science and new evidence. The second topic was sample cache development for Mars 2020, specifically with regard to the integrity of samples collected for eventual return. Thirdly, he raised the prospect of having new non-state and private actors in space that will require regulation in order to avoid contamination, to preserve NASA's interests.

Mr. Yoder supported a joint PPS/ESA meeting, which must be preceded by proper documentation, a statement of the objectives of the meeting, and selection of appropriate representatives. Addressing surface operations on Mars, he recognized that this is a rich discussion that needs to happen, and supported PPS efforts. As Mr. Yoder has taken over as the interface to the PPO, he also wanted to revisit policy and procedure requirements with a fresh set of eyes, to ensure that PP requirements are easily traceable, from a systems engineering perspective. Requirements must be clear and executable, following clearly laid out procedures. He would bring the results of the review back to PPS early in 2016. Dr. Lindberg agreed that the process has already benefited greatly from the MSL Lessons Learned report, which took a systems engineering approach to deriving Level-1 requirements.

Given that NASA does not have a return vehicle designed yet, Dr. Lindberg asked for a perspective on sample caching for Mars 2020. Mr. Yoder replied that preserving the scientific integrity of the samples is paramount. Dr. Rummel commented that the real issue is whether a credible quarantine can be effected, and whether terrestrial contamination of the samples can be avoided. The community would like assurance that Mars 2020 can put together an appropriate collection system and a cache that is returnable, both from a safety and scientific point of view. Dr. Boston noted that a great deal of engineering in previous missions had been carried out in ways that are incompatible with microbial decontamination methods and with appropriate life detection techniques; the tendency of missions to argue for "heritage" often overcomes the evolution of necessary techniques. Improving these techniques will make it less onerous to carry out PP protocols. Mr. Yoder agreed that technology investment in the present could reduce the burden or risk in future missions. He asked that PPS think carefully about evolving systems that will function as the basis for the next heritage systems. Drs. Rummel and Conley thanked Mr. Yoder for his increased support for planetary protection.

Working Lunch: Mars 2020 Update

Drs. Mitch Schulte and Matt Wallace presented an update on the development of the Mars 2020 mission, which has four objectives: establish geologic context in history; perform *in situ* astrobiology; enable the future by assembling a returnable cache of samples and filling HEOMD's SKGs; and demonstrating technologies for future Mars exploration.

Dr. Wallace (online) continued the briefing by describing the spacecraft, which borrows heavily from MSL. Mars 2020 is due to launch in July/August 2020, arriving at Mars in February 2021. Launch will take place at KSC, and the spacecraft will use an EDL system similar to that of MSL, but will have a smaller landing ellipse. Terrain relative navigation is being examined as a possibility, to enable hazard avoidance and to increase the number of scientifically interesting landing sites. The surface mission will span at least one Mars year, with a 20-kilometer traverse capability. Accomplishments in the past

year include a vigorous response to the AO for instruments. The payload will contain seven instruments, two of which are sponsored by HEOMD and the Science and Technology Mission Directorate (STMD). There will be a set of sensors on the backshell and heat shield to record pressure, temperature, etc. as the spacecraft lands. The first landing site workshop was held last year, and preparations are under way for a second. Thus far 25-30 sites have been evaluated, with the hope of a downselect to eight sites at the next workshop. The project is engaged in protecting the heritage of the system, and is getting key EDL and avionics vendors started. The mission transitioned into phase B in May with half of its electronics boards already built. There are four different test beds up and running for sampling and caching architecture. A payload system review was completed in March 2015, and KDP-C will be reached by the first quarter of 2016.

Dr. Schulte reviewed the instrument payload, which consists of MastCam Z, a camera system equipped with a zoom lens, and SuperCam, which uses some heritage from the MSL ChemCam. SuperCam provides laser-induced breakdown spectroscopy, remote green Raman capability and fluorescence spectroscopy, as well as visible-infrared spectroscopy, and microscopy. The rover's turret arm holds Scanning Habitable Environments with Raman & Luminescence for Organics and Chemicals (SHERLOC), a laser-induced fluorescence and Raman spectroscopy (244nm laser) instrument for identifying organic molecule classes (nature of bonds) at the thin-section scale, to 50-micron resolution. Also on the arm is Planetary Instrument for X-Ray Lithochemistry (PIXL), an x-ray fluorescence instrument that will provide data about major and minor elements, also at the 50-micron scale. PIXL also has a small micro-imager to chemically map rocks.

On the rover itself, the Norwegian instrument Radar Imager for Mars' subsurface experiment (RIMFAX) will provide ground-penetrating radar to map subsurface geologic structures. The Mars Environmental Dynamics Analyzer (MEDA) will measure temperature, humidity, and wind, and to analyze dust; MEDA is funded in part by HEOMD and STMD. The Mars Oxygen ISRU Experiment (MOXIE), an ISRU technology demonstration, converts CO_2 to CO and O_2, the latter for use as either breathable oxygen or propellant. SHERLOC has been augmented with WATSON, a Wide-Angle Topographic Sensor that will provide fine-scale imaging for organic and mineralogic detection.

Dr. Wallace reported that the mission is adding commercial cameras for parachute up-look, descent stage down-look, and rover up-look during EDL. The Mars 2020 sampling and caching system will acquire rock cores and regolith with a rotary percussive drill, which collects cores at the center of a bit, acquiring a sample directly into the sample tube, which is then sealed and cached for possible future return to Earth. The bit is taken back to a bit carousel, and the tube is extracted from the bit and then hermetically sealed. The system has been under development with Mars technology funding for quite some time. The final architecture review of the sample-caching system considered a monolithic vs. an adaptive cache. The advantage of a monolithic cache is

that it carries the individual sample tubes inside one container for retrieval. The inverse advantage to adaptive caching is that as soon as one gets to a point where sufficient samples have been collected, they can be offloaded. Tubes or a container left inside the vehicle are at risk of being left in a failed vehicle, presenting a huge challenge for the return vehicle. Another advantage is selectability; the rover can continue to collect samples after a set has been collected.

Dr. Lindberg asked if the caching scheme allowed for the possibility of collecting more mass than can be returned on one mission (more than 500 g). Dr. Wallace replied in the affirmative, adding that the Level 1 mission requirement is to collect 20 samples in the prime mission, but ideally the mission would like to collect a "superset" that would allow a science committee to choose which samples to retrieve. There are currently 52 sample tubes in the configuration; it's not clear whether that configuration will be the final one. The system includes control tubes and blanks. The tubes are hermetically sealed within two days of sample collection, but containment is a different issue. The tubes are not hermetically sealed while in flight to Mars; instead, a "tortuous path" seal is used to maintain organic and biological cleanliness. Dr. Lindberg expressed concern that volatiles from the spacecraft backshell may get driven into the tubes, and thereby present a recontamination problem. Dr. Wallace assured PPS that the mission understands that these issues need to be addressed and that the details will be tested. The challenging part of molecular contamination occurs after the tubes have been on the surface for some time.

The project has been doing a lot of drilling to ensure that the mechanical integrity of the core is preserved. Testing is ongoing, and it is thought there might be a need to have both percussive and rotary drills to address the full range of rocks. PPS requested more information on the engineering for the caching system on 2020: they wanted to hear about contamination issues related to depth, the degree of fracturing the sample will undergo, the heating of sample tubes *in situ*, materials (titanium, stainless steel, e.g.), types of seals, and fluid biobarrier materials. Mars 2020 Program Executive George Tahu agreed to arrange to get the information to PPS in the right detail after the PPS captured and provided its key concerns. Dr. Kaminski took the action to work with Mr. Tahu on this matter.

Dr. Lindberg asked about the overall system approach, and whether it was cleaner than MSL; his question arose from the concern that searching for the evidence of life with a non-sterile rover has a real potential to contaminate the Mars surface with Earth materials. Dr. Wallace explained that the mission requirements demanded that the team analyze contamination vectors; these were presented to the PPO's independent assessment team. One of the fundamental differences (between 2020 and MSL) is that 2020 is taking a transport analysis approach to both molecular and particulate contamination, which is then evaluated by a series of independent reviews and validation reviews. (detailed on slide 18 of the presentation). Dr. Lindberg requested a copy of the reviews to distribute to PPS.

Dr. Vigdor Teplitz, representing the Department of State, asked whether the team had taken new MSL findings on water distribution into account. Dr. Wallace reported that there have been no engineering impacts on the rover as yet, but the team is evaluating implications of hydration of minerals as they apply to special regions. Dr. Rummel asked that PPS be notified as the microbial details are clarified. He felt it would also be helpful to discuss plans for MOXIE and its potential to contaminate both the sample acquisition system as well as the surrounding area with hot gases that will condense very quickly.

Juno Update

Dr. Scott Bolton, PI for Juno, presented an update on the mission, which was launched in 2011 and is due to arrive at Jupiter by July 4, 2016. The spacecraft is healthy and all instruments are working. Science objectives include determining the oxygen/hydrogen O/H ratio to constrain core mass (origins); determining the interior structure by mapping gravitational and magnetic fields; mapping variations in atmospheric composition, temperature, cloud opacity and dynamics to depths of more than 100 bars at all altitudes; and characterization and exploration of the three-dimensional structure of Jupiter's polar magnetosphere.

The spacecraft payload carries X and Ka Band Gravity Science instruments, a magnetometer, microwave radiometers, low and high energy particle detectors to determine the Jovian auroral distribution, a radio/plasma wave experiment (Waves; University of Iowa), an ultraviolet spectrograph, visible camera, infrared camera and spectrometer. The instruments will probe the deep interior from orbit using microwaves, and sense the deep atmosphere through microwave measurements at 500-600 kilometers below the visible cloud tops. Juno will pass directly through auroral field lines, originating at the poles, while exploring the polar magnetosphere.

Recently, the mission changed the Jupiter orbit from 11 to 14 days in order to allow recovery from safe modes. Three additional days is significant for safe mode recovery, which is important as the mission is limited in time. The longitude build-up provides global coverage earlier in the mission, and in quadrants vs. hemispheres. The science became better as a serendipitous result. Every four orbits yield a coarse map of Jupiter, hedging against risk by providing a minimum success story early in the mission. The orbit also synchronizes intuitively with a seven-day work week. Perijove also passes over the Goldstone Deep Space Network complex. Dr. Conley noted that while the change in orbit has some PP implications, it is still compliant with PP requirements.

Dr. Bolton summarized the evidence supporting Jupiter as the oldest planet: Jupiter formed from the protoplanetary nebula after the Sun was formed and got more than half of the leftovers, thus it must have formed before the nebula disappeared. Jupiter is also so massive that it would have disrupted the formation of all the other planets had it formed after the other planets formed.

Public comment period

Daniel Peters of NY Skies commented that the meeting format was more educational than any NASA output yet encountered on Twitter and Facebook, and expressed a wish for video recordings in the future. Dr. Lindberg noted that minutes and presentations from the NAC subcommittee meetings are always publicly available.

Subcommittee Discussion/Recommendations

The PPS returned to a discussion of findings and recommendations. PPS proposed a restricted-Earth return Category V designation for Mars 2020. The subcommittee also considered identifying formal procedures for addressing planetary protection concerns in the midst of conducting surface operations, and suggested a workshop on possible special regions in Gale Crater as a case study for developing such a contingency action plan.

The PPS identified the following potential agenda topics for a future PPS meeting:

- Need for regulatory bodies to monitor the PP compliance of non-state actors.
- The possibility of InSIGHT contacting a *de facto* special region at 5 meters below the Mars surface. Dr. Conley mentioned that PP analysis showed that there are no hydrated minerals of concern, supporting InSIGHT's current categorization.

Drs. Kaminski and Conley were tasked to follow up on developing the agenda items.

The PPS also discussed fleshing out PPS agency representatives to include JAXA (Phobos/Deimos sample return); ISRO, UAE, EPA, OSTP, PCAS, Roscosmos, CDC, NIH, DHS (for their heavy investment in decontamination methods), FEMA, and FDA (molecular methods).

Other topics

- Marking of sample tubes for the 2020 mission: how to identify which 8-cc tubes are designated for the retrieval rover, and for the terrestrial laboratory.

Dr. Lindberg agreed to work with Dr. Kaminski to obtain the report of the PPO's independent assessment team, and to capture key concerns of the PPS concerning Mars 2020 to share with Mr. Tahu; and to determine the nature of Meeting of Experts (MoE) concerns, as well as that of the OCP minority opinion.

Dr. Lindberg commented that operations on the Mars surface involve three stakeholders: the PPO, the science teams, and the operations teams. It may be difficult to develop a list of indicators, and to develop *a priori* strategies on how to deal with unanticipated discoveries. Therefore there should be a contingency action plan that the project team can agree to. A rapid response team should include the PPO, and science and operations teams with equal voices around the table. There should be a Gale Crater "trailblazer" workshop, possibly with European counterparts, to review the science and continued plans for operation in view of the findings of frost, methane spikes, and RSLs.

Dr. Lindberg took an action to write the recommendation on the need for a contingency plan for operations in general, and a workshop for the particular case of Gale Crater.

Dr. Lindberg presented a certificate of appreciation to departing member, Dr. Miller, for his service.

Dr. Lindberg queried the table for concrete objectives for PPWG/PPS joint meeting. Ideas suggested included:

- Dr. Conley- Landing site selection, rover operations, PPWG perspective on documentation for returnable cache.
- Dr. Boston- comparison of relative advances in relevant PP technologies; discussion of current PP investments in ROSES. Identification of SKGs.
- Dr. Kminek- new manufacturing processes; additive layer manufacturing for polymers and metals. Discussion of iMars Phase 2 report elements regarding independent oversight of sample return.
- Dr. Rummel- European space operations in support of other nations; policy and legal aspects. Presentations about weather on Mars.
- Dr. Goeres- which standards organization to approach? International Organization for Standardization (ISO), Organization for Economic Cooperation and Development (OECD)?
- Dr. Goreva- standards need to be updated on a regular basis; it is unwise to fully rely on standard practices.

Dr. Kaminski made closing remarks and thanked members for attending, and identified the second week of December as a potential timeframe for next PPS meeting.

Dr. Lindberg adjourned the meeting at 4:09 pm.

Appendix A
Attendees

Planetary Protection Subcommittee Members
Robert Lindberg, University of Virginia, *Chair PPS*
Penelope Boston, New Mexico Tech
Colleen Cavanaugh, Harvard University
Peter Doran, University of Illinois, Chicago
Joanne Gabrynowicz, University of Mississippi
Darla Goeres, Montana State University
Yulia Goreva, Smithsonian Institution
Michael Imperiale, University of Michigan
Jon Miller, University of Michigan
Tullis Onstott, Princeton University
John Rummel, East Carolina University
Nick Steneck, University of Michigan
Meenakshi Wadhwa, Arizona State University (online)

U.S. Agency Representatives to the PPS
Kelvin Coleman, Federal Aviation Administration (online)
Dale Griffin, United States Geological Survey (online)
Vigdor Teplitz, Department of State

International Space Agency Representatives to the PPS
Vicky Hipkin, Canadian Space Agency (online)
Gerhard Kminek, European Space Agency

Amy Kaminski, *Executive Secretary PPS,* NASA HQ
Catharine Conley, *Planetary Protection Officer*, NASA HQ

NASA Attendees
Doug Bernard, NASA JPL
Dwayne Brown, NASA HQ
Steve Cole, NASA HQ
Jason Crusan, NASA HEOMD
Karen Fisher, OSMA, NASA HQ
Bob Gershman, NASA JPL
James Green, NASA HQ
Doug Isbell, NASA JPL
James Johnson, NASA JSC
Andrew Klesh, NASA JPL
Tomas Martin-Mur, NASA JPL

Michael Meyer, NASA PSD
Curt Niebur, NASA HQ
Marion Norris, NASA HQ
Ramon de Paula, NASA HQ
Betsy Pugel, NASA GSFC
Christy Rivera, NASA HQ
Mitch Schulte, NASA HQ
Bette Siegel, NASA HQ
Andy Spry, NASA JPL
Russell Stoewe, NASA HQ
George Tahu, NASA HQ
Cynthia Thomas, NASA HQ
Michelle Thaller, NASA HQ
Mary Voytek, NASA HQ
Jim Watzin, NASA HQ
Guy Webster, NASA JPL
Charles Whetsel, NASA JPL
Dan Woodard, NASA HQ

Non-NASA Attendees
Diane Brown
Stephen Clark, spaceflightnow.com
Dan Leone, SpaceNews
Daniel Peters, New York Skies
Tony Reichhardt, Air & Space Magazine
Amy Reis, Zantech IT
Perry Stabekis, Consultant
Dan Vergano, BuzzFeed News
Joan Zimmermann, Zantech IT

Appendix B
Committee Membership

Robert Lindberg, Chair
University of Virginia

Catharine Conley, Planetary Protection Officer
NASA Headquarters

Amy Kaminski, Executive Secretary
NASA Headquarters

Penny Boston
New Mexico Tech

Colleen Cavanaugh
Harvard University

Peter Doran
Louisiana State University

Joanne Irene Gabrynowicz
University of Mississippi School of Law

Darla Goeres
Montana State University

Yulia Goreva
Smithsonian Institution

Michael Imperiale
University of Michigan

Jon D. Miller
University of Michigan

Tullis Cullen Onstott
Princeton University

John D. Rummel
East Carolina University

Nicholas Steneck
University of Michigan

Meenakshi Wadhwa
Arizona State University

Agency Representatives:

Kelvin Coleman
Federal Aviation Administration

Dale Griffin
United States Geological Survey

Victoria Hipkin
Canadian Space Agency

Gerhard Kminek
European Space Agency

Vigdor Teplitz
Department of State

Michel Viso
CNES/DSP/EU

Subcommittee Administrative Support:

Ann Delo
NASA Headquarters

Appendix C
Presentations

1. Planetary Protection Overview; *Catharine Conley*
2. Planetary Protection Issues and Updates; *Catharine Conley*
3. Planetary Protection Strategic Knowledge Gaps Workshop; *Bette Siegel*
4. Mars Exploration Program Update; *James Watzin*
5. Mars InSIGHT; *Joel Krajewski, Andy Klesh, Jason Willis*
6. NRC Report on Sample Contamination, Mars Sample Return; *Catharine Conley*
7. NASA Communications Campaign Overview; *Dan Woodard*
8. ESA Planetary Protection/COSPAR Update; *Gerhard Kminek*
9. Mars 2020 Update; *Mitch Schulte, Matt Wallace*
10. Juno Mission Briefing; *Scott Bolton*

Appendix D
Agenda

NASA Planetary Protection Subcommittee
Meeting Agenda
June 8-10, 2015
NASA Headquarters, Room 6H41
In-person and remote access details listed at end of agenda

June 8, 2015

1:00 pm	Welcome/orientation/introductions	Amy Kaminski, NASA HQ Robert Lindberg, Univ. of Virginia
1:15 pm	Planetary protection overview	Cassie Conley, NASA HQ Gerhard Kminek, European Space Agency
4:00 pm	Adjourn for the day	

June 9, 2015

8:30 am	Welcome, orientation, introductions	Amy Kaminski, NASA HQ
8:45 am	Words from the PPS chair	Robert Lindberg, Univ. of Virginia
8:55 am	Planetary protection issues and updates	Cassie Conley, NASA HQ
9:45 am	Planetary Protection Knowledge Gaps Workshop	Cassie Conley, NASA HQ Bette Siegel, NASA HQ
10:30 am	Break	
10:45 am	Planetary Sciences Division update	James Green, NASA HQ
11:30 am	Mars Exploration Program update	James Watzin, NASA HQ
12:15 pm	Subcommittee discussion	
12:45 pm	Lunch on your own	

1:45 pm	Mars InSight mission update/MarCO CubeSat update	Jason Willis/ Joel Krajewski Jet Propulsion Laboratory
2:45 pm	Report from National Research Council meeting of experts on sample contamination for Mars Sample Return	Cassie Conley NASA HQ
3:30 pm	Break	
3:45 pm	NASA communications campaigns overview	Dan Woodward, NASA HQ Ashley Edwards, NASA HQ Michelle Thaller, NASA HQ Derek Wang, NASA HQ
4:30 pm	Public comment period	
4:40 pm	Subcommittee discussion	
5:15 pm	Adjourn for the day	

June 10, 2015

8:30 am	Annual ethics briefing (PPS members only)	James Reistrup, NASA HQ
9:30 am	Welcome/overview of the day	Amy Kaminski, NASA HQ Robert Lindberg, Univ. of Virginia
9:35 am	European Space Agency (ESA) planetary protection/ Committee on Space Research (COSPAR) update	Gerhard Kminek ESA
10:30 am	PPS/ESA Planetary Protection Working Group joint meeting discussion	Robert Lindberg/all
11:15 am	Break	
11:30 am	Discussion with Science Mission Directorate Deputy Associate Administrator	Geoff Yoder, NASA HQ
12:00 pm	Subcommittee discussion	
12:20 pm	Pick up preordered lunches (PPS members only)	

12:30 pm	Working lunch: Mars 2020 update	Matt Wallace Jet Propulsion Laboratory
1:30 pm	Juno mission update	Scott Bolton, Southwest Research Inst.
2:15 pm	Break	
2:30 pm	Public comment period	
2:40 pm	Subcommittee discussion/recommendations	
4:00 pm	Adjourn meeting	

MEETING ACCESS INFORMATION:

The meeting will be open to the public up to the capacity of the room. Attendees will be requested to sign a register and to comply with NASA security requirements, including the presentation of a valid picture ID to Security before access to NASA Headquarters. Foreign nationals attending this meeting will be required to provide a copy of their passport and visa in addition to providing the following information no less than 10 working days prior to the meeting: full name; gender; date/place of birth; citizenship; visa information (number, type, expiration date); passport information (number, country, expiration date); employer/affiliation information (name of institution, address, country, telephone); title/position of attendee; and home address to Ann Delo via email at ann.b.delo@nasa.gov or by fax at (202) 358-2779.
U.S. citizens and Permanent Residents (green card holders) are requested to submit their name and affiliation 3 working days prior to the meeting to Ann Delo.

The meeting will also be available telephonically and by WebEx. Any interested person may call the USA toll free conference call number 844-467-6272, passcode 197792, to participate in this meeting by telephone. The WebEx link is https://nasa.webex.com/. The meeting number on June 8, 2015, is 999 084 742, passcode pps06082015!. The meeting number on June 9, 2015, is 998 176 277, passcode pps06092015!. The meeting number on June 10, 2015, is 998 424 135, passcode pps06102015!.