NASA ADVISORY COUNCIL

PLANETARY PROTECTION SUBCOMMITTEE

November 12-13, 2013

Goddard Space Flight Center
Greenbelt, MD

MEETING MINUTES

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Eugene Levy, Chair

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Gale Allen, Executive Secretary

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Prepared by Elizabeth Sheley
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Tuesday, November 12

Welcome, Orientation, Introductions

Dr. Gale Allen, Executive Secretary of the Planetary Protection Subcommittee (PPS), opened the meeting by noting changes in the agenda. She explained that NASA was discussing possible changes in the advisory committee structure, with the goal of making the committees and subcommittees more effective.

Words from the Chair

Dr. Eugene Levy, PPS Chair, expressed optimism about the potential changes in the advisory committee infrastructure. He expected a great deal of discussion to grow from the presentations at this meeting.

Remarks from NASA Chief Scientist

Dr. Ellen Stofan, NASA Chief Scientist, explained that her office has three primary functions:

- Advise the NASA Administrator on the science implications of Agency policy;
- Advocate on NASA science issues to Congress and the White House; and,
- Represent NASA science to the public and the science community.

This subcommittee is of particular interest to her office, as it cuts across various NASA directorates. It is critical to understand how to conduct planetary protection for further activities on Mars, especially with the goal of human exploration on Mars.

Planetary Science Division Status

Dr. Jim Green, Director of the Planetary Science Division (PSD), began his update on Division activities by discussing budget issues. The President’s FY14 budget request for PSD totals $1,217,600, of which $50 million is for the Department of Energy (DOE) PU-238 infrastructure and $20 million is allocated for Near Earth Object (NEO) identification. Currently, PSD is operating under a continuing resolution (CR) and is technically allowed to spend at the FY13 rate, which is higher. However, the Division is actually spending at the proposed FY14 rate.

PSD has sponsored a number of events. There is a “Mars as Art” exhibit at Dulles Airport. July saw the “Wave at Saturn” event. The 1-year anniversary of Curiosity landing on Mars occurred in August, and on September 6, the Lunar Atmosphere and Dust Environment Explorer (LADEE) launched from the Wallops Flight Facility in Virginia. An anomaly occurred with the Balloon Rapid Response for ISON (BRRISON) payload in September.

The Division will launch the Mars Atmosphere and Volatile Evolution (MAVEN) mission on November 18 and the Far-ultraviolet Off Rowland-Circle for Imaging and Spectroscopy (FORTIS) experiment will take off the next day to observe Comet ISON. The Venus Spectral Rocket Experiment (VESPR) will launch on November 25 in order to observe Venus.

The White House has proposed major changes in education and public outreach (E/PO) at the science agencies, including NASA. Under the CR, all of PSD’s E/PO projects continue as planned for FY13. As of yet, there will be no implementation of the proposed E/PO consolidation.

PSD won four “Webby” awards for its websites, two for the Division website and two for Curiosity’s social media site. In the “Wave at Saturn” event, thousands of people worldwide waved as the Cassini mission took a photo of Earth. This had strong media participation, which helps engage the public and let them know the value of the missions.

Dr. Green described the LADEE launch, which was seen by millions of people along the east coast. The mission has been inserted at the moon and is doing quite well, with instruments making some great measurements already. A laser communications system designed to send and accept high-rate data has been working flawlessly. LADEE has demonstrated some remarkable capabilities with its communications system. For example, it can switch from one station to another, it has shot through some clouds, and it has acquired a signal at a low horizon. The high data transfer rates allowed the mission team to correct an anomaly within minutes. A system like this would be helpful on future Mars missions.

Dr. John Rummel asked if LADEE can determine the volatile inventory. Dr. Green replied that the material from a comet hitting the moon would disperse material that would be observed. In December, China will launch an observer that will land on the moon, and NASA expects LADEE to see that. In response to another question, Dr. Green said that the Lunar Reconnaissance Orbiter (LRO) takes very sensitive temperature data, but he was not sure if it can distinguish ice composition. The moon does out-gas, especially when it is in Earth's magneto tail. Moonquakes also occur, with possible gas releases. Dr. Rummel observed that the inclusion of cyanide in moon volatiles indicates there could be cyanide in asteroid materials, complicating the possible asteroid retrieval project.

Dr. Green said that one year ago, there were not yet plans for a Mars 2020 mission. NASA had backed out of the European Space Agency (ESA) plan, though NASA continues work on Electra (telecommunications radios) for the Trace Gas Orbiter (TGO) and the ExoMars Rover (MOMA). Today a year later NASA was having a Key Decision Point-A (KDP-A) meeting on Mars 2020. PSD has received notices of intent, and proposals will be due in January.

Curiosity indicates that Mars has lost 85-95 percent of its atmosphere. MAVEN will look at this and the loss of the magnetic field, determine the composition and structure of the current upper atmosphere, determine rates of loss of gas to space today, and take measurements to help gauge the integrated loss to space over time.

Congressional action in 1998 required NASA to find 90 percent of NEOs larger than 1 kilometer within 10 years; a 2005 bill required the Agency to locate 90 percent of the NEOS larger than 140 meters within 15 years. While the former has been largely accomplished, the latter has proven difficult. However, PSD has an enhanced observation program, NEO Wide-field Infrared Survey Explorer (NEO-WISE), built on a former Astrophysics Division (APD) program. NEO-WISE is expected to find some objects that are closer to Earth. In addition, a new telescope at the University of Hawaii, Panoramic Survey Telescope and Rapid Response System (PANSTARRS), is now operating.

NASA is studying a mission to capture and retrieve an asteroid of about 7 meters, bring it to trans-lunar space, then have humans go to the moon and retrieve samples for return to Earth. PSD's role is to identify and characterize appropriate targets. This is not a science mission, but rather it is largely a technology demonstration program.

PSD is moving to the next KDP on the existing Discovery mission. The Division received 57 responses to its Request for Information (RFI) call and is now analyzing those responses before sending them out to the community for more discussion. Due to the budget, it is not clear when the next Discovery AO will occur, but PSD will prepare a draft for when the budget does allow.

The last Senior Review saw many missions go into extended mission mode for FY13 and FY14. Funding for extended missions remains stable, but the Curiosity mission will be subject to the next review, and it is expensive to operate. The result is that the budget will be tight despite the exit of the Messenger mission. The Division will issue guidelines early in 2014.

As mentioned, there was a problem with BRRISON. At about 90,000 feet, the telescope made the initial observations but then went beyond the normal position and became stuck. Fortunately, the team was able to retrieve the payload, which was in excellent shape and can be refurbished for future use after the cause of the anomaly is identified and addressed.

FORTIS is co-funded by PSD and APD, and will look at Comet ISON, which is brightening. VESPR will travel to Venus to study the current escape of water from the atmosphere and relate it to the past abundance of water on that planet.

The Research and Analysis (R&A) program has just announced the nine teams selected for the Solar System Exploration Research Virtual Institute (SSERVI), a newly chartered institute addressing PSD and Human Exploration and Operations Mission Directorate (HEOMD) interests. The SSERVI budget is $13 million per year, about $5 million of which comes from HEOMD.

PSD is also restructuring its R&A program. The program began with a few core focus areas a long time ago, then kept growing with no changes. The restructured program has well-defined objectives that will be best addressed through this consolidation. With the reduced budget and more scientists, this is necessary. The restructuring will help better explain the program to those outside NASA so that they understand where the funding goes, reduce the time from proposal submission to award, encourage interdisciplinary research, enable strategic decision-making, enhance flexibility, and reduce overlap.

An example of interdisciplinary research is climatology and solar wind impact, which cuts across several SMD divisions. As currently structured, the R&A program does not have a place for proposals in this area. SSERVI is also cross-cutting. The new structure will not include data analysis, planetary protection, or data analysis of returned samples. The restructuring will be in effect for the Research Opportunities in Space and Earth Science (ROSES) 14 call. PSD plans a series of roll-out events with the community before then.

Discussion
Dr. Rummel noted that the science definition team (SDT) for Mars 2020 said that this would be a returnable sample mission with a cache of samples worth analyzing, which involves not including contamination by Earth life taken to Mars. Planetary protection will be a factor. However, the AO appeared to have no room for planetary protection and did not spell out the requirements for any heat treatment. There is the option of submitting a one-page appendix, but he was not sure proposers know what they will be asked to do. Dr. Green said that any questions should be submitted, and the answers will be posted. Dr. Andrew Steele said that planetary protection should be folded into the design, as planetary protection and science go hand in hand.

Dr. Levy asked whether the spacecraft design would be decided after the science instruments are selected. Dr. Green explained that the basic architecture is that of the Mars Science Laboratory (MSL). Instruments will be competed as part of the Phase A study. PSD will then begin instrument selection and accommodation. The baseline power is selected; the operating characteristics require sustainable power, not renewable power. The Multi-Mission Radioisotope Thermoelectric Generator (MMRTG) is the baseline, and Mars 2020 will use Curiosity's spare. The plutonium is available.

The Dawn mission is doing great despite having lost a reaction wheel and will reach Ceres in Spring, 2015. The prime mission will begin at that time, and Dawn will go to the senior review in 2016. At this point, Mars 2020 is the biggest concern in terms of planetary protection.

<u>Status of NASA Planetary Protection</u>

Dr. Catharine Conley, NASA's Planetary Protection Officer (PPO), noted that with an overarching goal to expand scientific understanding of the Earth and universe in which we live, many of PSD's sub-goals relate to planetary protection.

NASA addresses planetary protection through NPD 8020.7G, which covers planetary protection policy, and in NPR 8020.12, which contains the requirements for robotic missions. These reflect NASA's agreement to the Outer Space Treaty standards developed by the Committee on Space Research (COSPAR), an international body. NASA also obtains recommendations on planetary protection issues from the National Research Council (NRC) Space Studies Board, and receives policy implementation advice from PPS. NPR 8020.12D encompasses documentation and implementation requirements for forward and back-contamination control on robotic spacecraft, while also specifying compliance with COSPAR. International missions must also follow COSPAR policy. A draft NASA procedural requirements document for HEOMD is being prepared, and preparatory activities are in process.

Coordination and Advice

The role of PPS is to provide expert advice to NASA on planetary protection. The Subcommittee needs to have a broad composition, including biologists, planetary scientists, and social sciences experts such as lawyers, ethicists, and others needed to address the relevant issues. PPS also has ex officio representation from other U.S. government agencies and international groups. Cooperation and coordination are increasingly relevant as activities go beyond NASA.

Dr. Conley works closely with ESA and has had the Japanese Space Agency (JAXA) give a presentation at a PPS meeting. She would like to have an ex officio representative of the Russian Federal Space Agency, Roscosmos, join the PPS, and as well as a representative from the Indian Space Research Organization (ISRO). Specifically in the context of joint advisory meetings with ESA, the constrained NASA travel budget has affected these interactions. Within NASA, planetary protection goes beyond SMD. Dr. Conley showed a graphic representation of the Office's interests in policy, technology, science, and implementation, along with the many NASA organizations involved. Similar coordination occurs in these areas outside of NASA.

Dr. Levy said that Mars One, a commercial effort in the Netherlands to launch a one-way human exploration trip to Mars, could make this all moot. SpaceX, a U.S. commercial space corporation, is involved. Dr. Conley explained that this is an instance in which NASA has interest in terms of future science and communications abilities, but the United States does not otherwise have a policy beyond the treaty licensing. Dr. Joanne Gabrynowicz explained that if the Dutch are to launch anything, they have to obtain a license. If the entities are U.S. or European, they are bound to continually supervise their activities. There was a company Sea Launch that tried to evade international regulations by launching from the Pacific Ocean. However, there are ways to exercise jurisdiction beyond the location of the launch, which is what occurred with that effort and ought to occur with Mars One.

Although the Federal Aviation Administration (FAA) might receive a request to issue a launch license, this could take a while because this would be the first time for such an effort, and the export would be subject to Department of Commerce (DOC) scrutiny. Dr. Rummel added that the State Department must work with other government entities to ensure compliance with the Outer Space Treaty. It is still not clear whether NASA will be involved, beyond the existing advisory role with the FAA. Dr. Gabrynowicz noted that NASA is not a regulatory agency, but the regulatory agencies will need NASA input. Dr. Vigdor Teplitz reported that the State Department had discussed this issue.

Dr. Conley explained that the Planetary Society successfully exported to RosKosmos an item that was to go to Mars on the Phobos Grunt mission,that went through standard DoC export processes but that planetary protection was apparently not considered in this process. The hardware had live organisms, which could have been an issue. NASA and ESA planetary protection became involved due to the use of NASA and ESA assets by RosKosmos' mission. Dr. Gabrynowicz thought that DOC personnel probably did not consult NASA because they did not think they had to; they probably do not think about planetary protection. If NASA is to be involved in these processes, there must be a concerted interagency process. Ms. Robin Frank, from NASA's Office of General Counsel (OGC), said that there was not a clear mandate for planetary protection responsibility outside of NASA. Dr. Robert Lindberg observed that the gatekeepers are established, but the processes for gatekeeping are porous. Some of this could be elevated to the Office of Science and Technology Policy (OSTP), which should rationalize practices across U.S. government agencies. Dr. Rummel added that while NASA has no interest in being a regulatory agency, whoever has that authority must pull NASA in to the process.

Dr. Conley next reviewed the status of NASA's response to prior PPS meeting recommendations. Everything has been completed or is in process, with the exception of a recommendation for joint meetings with ESA, which has been affected by the Federal government travel restrictions.

Her primary programmatic concern has to do with the much wider variety of activities at NASA that call for involvement of the Planetary Protection Office. To address this increase in the face of a flat budget, Dr. Conley has brought in several very knowledgeable detailees and contractors to extend her capacity. Ultimately, however, the capacity of the Office to support research has dropped, with no ROSES solicitation scheduled for 2014.

Current and Upcoming Missions

If the Dawn mission successfully enters orbit around Ceres, it will be going so fast that impact avoidance is assured. The trajectory analyses show that this will indeed be the case. The Interior exploration using Seismic Investigations, Geodesy and Heat Transport (InSight) mission to Mars will implement planetary protection requirements appropriate for a Category IVa mission, as previously discussed with the committee. The Europa Clipper concept has significant planetary protection technology development needs, which are addressed in the plan but are still undetermined. Future sample return missions face organic contamination constraints driven by science and relevant to future planetary protection implementation concerns. One aspect of this issue may be addressed through a Centennial Challenge competition on clean sample handling. Refinement of planetary protection requirements for a Mars Sample Return (MSR) campaign is essential to support Mars 2020. This mission must address issues of a returnable cache.

HEOMD Plans for Planetary Protection

Dr. Bette Siegel, of HEOMD, reported that the NASA Advisory Council (NAC) recommended that HEOMD create an implementation document specifying planetary protection procedures; this recommendation was accepted and HEOMD is moving forward. The document will put NASA in compliance with its own policy, and support United States compliance with the Outer Space Treaty. She and Dr. Conley are leading the core document development team, which has representation from across NASA.

At the core team's first meeting, they realized that they do not have the necessary technical requirements to draft a sufficiently detailed NASA Procedural Requirements (NPR) document, which led them to instead begin drafting a NASA Procedural Instruction (NPI) document. An NPI has a number of advantages. It must be followed by the entire Agency, anticipates the development of an NPR, incorporates COSPAR policy, and does not need specific requirements.

Ms. Frank added that an NPI is not in lieu of an NPR. This NPI will lead to an NPR. It essentially states that there is a draft NPR and that NASA is committed to following COSPAR principles. Dr. Siegel agreed that the NPI explicitly contemplates an NPR, and noted that it specifies next steps. The plan is to finalize the NPI by the end of January.

One of the Office of Planetary Protection detailees will do a literature search on studies that have already been done. They will then plan a workshop, target of summer 2014, to identify which other studies are needed, and plan on a Memorandum of Understanding (MOU) with the relevant directorates, target latter half of 2014, as to what steps are necessary and who pays for them. Once the requirements are identified, the team will draft the NPR. Dr. Rummel believed they were on the right track. The requirements must be able to hold the appropriate parties accountable, and the team is not there yet.

Planetary Protection at ESA: Issues and Status

Dr. Gerhard Kminek, the PPO at ESA, presented an overview of that agency's activities.

In a review of selected missions, Dr. Kminek explained that the BepiColombo mission will be at Planetary Protection Category II, due to the need for a Venus gravity assist. The Solar Orbiter, in which NASA provides the launch vehicle, will go up from Kennedy Space Center (KSC) in 2017. It, too, is a Planetary Protection Category II due to a Venus gravity assist. There is a requirement for a demonstration of the launch vehicle probability of Mars impact, which will be discussed with NASA. The Jupiter Icy moon Explorer (JUICE) is an ESA-led mission to the Jovian system, with a focus on Ganymede and Europa. With a launch anticipated in 2022, Phase A has just been completed. It is a Planetary Protection Category III mission. The planetary protection approach for Europa has been agreed upon, and the planetary protection approach for Ganymede is under review.

One of the candidate missions, Phootprint could go to Phobos, a Martian moon. It would be at Planetary Protection Category V. Determination if this is unrestricted or restricted Earth return is underway and linked to a U.S. contribution dealing with the modeling of material transfer from Mars to Phobos, which is the critical issue. A down-selection is planned within the next two years . Results of a dedicated test activity to support the mission categorization will be published in a peer-reviewed journal, at which point the European Science Foundation (ESF) and others will study the results and make recommendations that will be forwarded to COSPAR. Another candidate mission is MarcoPolo-R, which would return samples from asteroid 2008EV5. Phase A has been completed, and ESA will confirm that this is Planetary Protection Category V, for an unrestricted Earth return. There will be a similar process of peer-reviewed journal publication and ESF review.

R&D has been completed on several projects of interest. The update of dry heat microbial reduction specification is a joint activity with NASA. Dry heat has already been used at the ExoMars project level. Another R&D project is the source-specific encapsulated bioburden, with five materials typically found on flight systems. This will be used for ExoMars 2016. An additional R&D result is the introduced rapid microbial assay, which ESA published as an approved method. Instead of waiting 3 days for final results, this method provides results within 7 hours, while also reducing the number of plates substantially.

Current R&D includes an update of the interplanetary micro-meteoroid model and consolidation of the interplanetary micro-meteoroid environment. ESA intention is to continue work on the in-flight containment system for a MSR mission to increase the Technology Readiness Level (TRL), as not all technology challenges have been sufficiently resolved.

A project to evaluate aspects of biohazard assessment on samples returned from Mars focuses on statistically relevant sub-sampling of samples returned from Mars in order to evaluate with high confidence whether the samples are safe for release from containment. Two independent teams are working on this in parallel and in competition. They have used very different approaches to come to similar results. The final project Dr. Kminek discussed was a double-wall isolator system for samples returned from Mars. This system has been identified as key element for an MSR containment facility. The study's emphasis is on containing the returned samples while keeping their quality intact.

Discussion
Dr. Rummel asked if the development activities focused on sample return are related to the NASA 2020 mission. Dr. Kminek said that there are some sample returns elements among the candidate missions (e.g. Phootprint, Marco-Polo R). The first in-flight containment breadboard tests for a MSR mission did not go well, but the current system tests are quite positive. Yet not all of the problems have been solved.

Regarding system compatibility of a potential 2020 cache with the containment system currently under development at ESA, Dr. Kminek explained that the ESA development is about containment and containment monitoring of a system that contains the samples (i.e. cache). The caching system is not part of the current ESA development. He was not aware of what NASA is doing in regard to caching and the canister. Dr. Steele asked how the rapid assay dropped from 3 days to 7 hours. Dr. Conley said that it looks at tiny colonies (using bioluminescence detection in an automatic system). Dr. Kminek added that different media are used in the NASA and ESA Standard Assays. Dr. Conley noted that NASA and ESA colony counts give the same answer despite being on different media.

Dr. Conley explained that in joint projects with ESA, the NASA funding comes from the programmatic side of her budget. In the past, there has been a good deal of funding from the Mars program for planetary protection technologies relevant to Mars. There is plenty of work to be done, but the limited budget means that little is currently being developed on the NASA side. Dr. Rummel observed that the fast assay will save money, but NASA occasionally develops a short-term mentality regarding technology. Dr. Rummel pointed out that politics can affect technology support at NASA. Dr. Kminek addressed the differences between ESA and NASA, explaining that ESA has different technology domains. He participates in the technology development meetings and can bring up issues right away. It makes it easier than at NASA, where Dr. Conley has not had that option. Also helpful is the large number of ESA people who have attended a planetary protection course, which makes them sensitive to the issue. While the courses are not mandatory, they are often taken to meet education requirements for projects, as all project personnel are required to receive training in planetary protection. There are different levels of courses according to the work requirements of the individuals. Since ESA started launching planetary missions more recently than NASA, these courses were considered necessary.

Dr. J. Andy Spry noted that he is developing a similar set of courses as one of his tasks for the Office of Planetary Protection. A person cannot handle something in a clean room without going through the full course, for example, and there is also an overview course. Dr. Perry Stabekis added that NASA project managers may feel that they have been exposed to planetary protection already and therefore do not need additional instruction. Dr. Levy said that in addition to the training issue, the role of planetary protection in technology development at NASA varies. Sometimes it is left out, and sometimes it is seen as key. Dr. Conley said that HEOMD seems to be recognizing that planetary protection is necessary and is developing plans to address issues with a roadmap as part of the NPI/NPR development process.

Dr. Stabekis said that it is essential to ensure that Planetary Protection is incorporated into all requirements, which was the case during the Viking mission. Dr. Levy said that it would be useful to have a list of technology development needs. Dr. Conley replied that a draft paper has some of them; Dr. Levy suggested that an abstract would be useful. Dr. Conley added that JPL did an inventory study in 2012 that she would bring forward. Dr. Levy would like to see the NASA Office of the Chief Technologist (OCT) take this up in a serious way.

S&MA Technical Authority

Dr. Lindberg said, in some introductory remarks, that Ms. Dierdre Healey, of NASA's Office of Safety and Mission Assurance (OSMA), had been invited to speak at his request. Over the past several PPS meetings, there had been discussions about planetary protection relative to the role of the projects supported, as well as about the relevance of planetary protection beyond SMD, into HEOMD and STMD. He had thought about the longstanding relation of safety assurance to NASA's project goals, and believed they do not always have the same objectives. Therefore, he thought it would be good to hear from OSMA about how the safety and mission assurance (S&MA) process dovetails with planetary protection.

Ms. Healey explained that OSMA is one of three technical authorities at NASA that were created after the Challenger disaster. One purpose is to have an independent appeal path for S&MA issues. OSMA differs from the other two technical authority offices (Office of the Chief Engineer (OCE) and Office of the Chief Health and Medical Officer (OCHMO)) in that it has a different line of funding for technical authority. OSMA has a chief safety officer for each program and project, and the chief safety officer at each center reports through the center directors to the head of OSMA. The chief safety officers have an independent appeal path. Any appeal must be heard at the next level until it is independently agreed upon by all parties.

Dr. Lindberg noted that the independent avenue is an important part of the "healthy tension" in achieving NASA's goals. In industry, engineers often saw that the safety team had a different focus: engineers had an incentive to have mission success, while the safety team goal was to operate safely. The latter were centered on the safety of the crew, other personnel, and the public. There is a difference in the safety side of S&MA and the mission assurance side. Planetary protection has interests on both sides of that ledger, while also being aligned with the science objectives in protecting the viability of a site for future science. NASA's Office of Planetary Protection supports US treaty obligations, as well. Dr. Conley said that there is currently a NASA Policy Document that covers all of NASA, and an NPR that covers robotic mission, but no NPR for human exploration yet the path to achieve this was described earlier. The NPD is at the level of the Administrator and applies to all of NASA. There needs to be greater recognition of that.

Dr. Lindberg explained that OSMA has a process by which noncompliant actions are made compliant, along with an incentive to prevent noncompliant actions from occurring in the first place. He wondered how often OSMA exercises that authority within NASA, and at what level. Ms. Healey said that this does not occur often, though it does happen. Most cases are discussed before there is a formal process, and this takes place at all levels. For example, at Headquarters, there have been two formal hearings resolved at the mission directorate level, and nothing has gone up to the Administrator as of yet. This promotes resolution, in part because of the consequences of the more formal hearing.

Dr. Lindberg suggested that in the incidents where a disagreement rose very late regarding planetary protection, the issues might have been resolved earlier had the Planetary Protection Officer had some of the operating abilities of OSMA. Dr. Conley said that the way planetary protection is treated within formal requirements documents is inadequate, according to an analysis to be presented the next day. Her office will study that report once it is issued. She would like to see a well-integrated, formal process.

Ms. Healey said that OSMA holds the program or project manager responsible for meeting all requirements. Dissenting opinions are less about actual compliance and more about residual risk, which can be a source of substantial disagreement. Dr. Lindberg noted that often there are mitigations that are not considered sufficient and result in an escalation. The issue is more one of the characterization of residual risk and how that is viewed.

Dr. Conley said that, from a historical standpoint, the Viking project had something similar to S&MA. Over time, however, the extensive infrastructure from Viking disappeared. It became an issue once again with Pathfinder, at which point the function began coming came back in pieces, with most of the structure left out. There may have been a failure of understanding. Dr. Rummel said that planetary protection has not been done at the same level as for Viking. The funds did not exist to hire a formal specialty for Pathfinder, so an ad-hoc team was eventually created to address compliance for that project. The level of support for Viking was robust, with biological contamination reduction compatibility being a major design driver.

Dr. Kminek explained that within ESA, planetary protection is in the same organization as mission assurance and safety, and the structure makes it independent of any program lines. At NASA, it is easier to talk with the programs and projects within the Science Mission Directorate, while ESA's advantage is that he is at the same site as the projects and sees the people daily. Dr. Levy said that even leaving HEOMD aside, the situation at NASA is not perfect for planetary protection in SMD. Dr. Rummel noted that the SMD Associate Administrator has always been more likely to support this function. However, compliance with treaty obligations may be less closely aligned with SMD. Dr. Stabekis brought up the idea of moving it to the Office of the Administrator, as that is where it would receive the most backing for an agency-wide requirement.

<u>Sample Analysis at Mars (SAM) Presentation</u>

Dr. Paul Mahaffy, PI for SAM, discussed early results from the Curiosity Rover's SAM investigation at Gale Crater. Curiosity's primary scientific goal is to determine the habitability of the Mars surface, either now or in the past. This involves assessing the biological potential, geology and geochemistry, the existence and availability of water, and surface radiation. Gale Crater was formed about 3.6 billion years during an interesting time of change on Mars, which makes it especially appropriate for study.

Thus far, the SAM team is happy with what the instrument has provided. Dr. Mahaffy described the operations of the SAM instrument, which relies on chemistry and isotopes for its measurements. The Alpha Particle X-Ray Spectrometer (APXS) provides further analysis. Dr. Mahaffy presented a gas flow diagram of how atmospheric gas or vapors are extracted from solids for analysis in the three SAM instruments: the Quadrupole Mass Spectrometer (QMS), Tunable Laser Spectrometer (TLS), and the Gas Chromatograph System.

The next target was Yellowknife Bay, where Curiosity found calcium sulfate/gypsum. Cross-bedded layers are indicative of past water flow, and abundant clays indicate sustained interaction with water. These results are in the final stages of being published. SAM provided evidence of high temperature water evolution, another indicator of clay. The team is still trying to figure out the meaning of the carbon dioxide, and has many experiments designed to understand it. Ultimately, SAM shows that this was an aqueous environment, and not highly acidic. The elements that life needs were all present. Energy gradients were also there.

The team started atmospheric runs with a direct atmospheric analysis, then scrubbed out the active gases to get noble gases in order to identify the trace noble gases. The team is seeing more argon to nitrogen than did the Viking mission. SAM has generally run at night because methane operates cold and Curiosity does not move then, which works best for the team charged with that aspect of the operations. Dr. Mahaffy showed the laser absorption spectroscopy data with the methane absorption lines and the very narrow spectral region that is scanned.

The Rocknest early results show deterioration to atmosphere ratio of about six times that on Earth. Dr. Mahaffy showed the SAM QMS enrichment experiment on sol 231, which produced a very precise number and is quite different from other places in the universe. The SAM team will use this to measure atmospheric escape. Isotopes point to atmospheric loss. The SAM instrument suite measures atmospheric isotope ratios. In the last 3.5 billion years on Mars, activity has slowed down, including thermal-chemical escape. The escape processes will be measured by MAVEN, as part of a huge modeling effort to go back in time. Up to 95 percent of the methane on Earth is from life sources. On Mars, that might have been produced by microbes, and might have been stored or released by non-biogenic processes. Methane in the atmosphere lasts about 350 years or so. The SAM team did not detect methane, which suggests, if it is present, it's at less than 1.3 parts per billion. They will keep looking and do another type of experiment as well. The team tracks seasonal changes of argon and nitrogen, which does show a response to the polar expansion and retraction.

Discussion
There have been no unpredicted signs of rare metals, Dr. Mahaffy said. Regarding any advice he would provide for the design and operation of future projects, he noted that Curiosity is very complex and is going slowly. Much focus was getting safely to the surface, with less emphasis on the early development of the sampling system. There were things that could have been tested beforehand. He believes it is now necessary to give more attention to sample handling. Curiosity investigators are finding out that the damage to biosignatures can be much more dramatic than had been previously thought. The implications of radiation on drilling and planetary protection both deserve careful attention.

Dr. Rummel asked if any of the methane results are tied into perchlorates or other surface materials. Dr. Mahaffy replied that they had not had much discussion regarding whether the oxidized nature of the surface could be a direct mechanism for destroying methane. The other side is a study of radiation.

Dr. Levy announced that PPS would visit Dr. Mahaffy's lab the next day.

ExoMars/MOMA Presentation
Dr. Kminek focused this discussion on ExoMars, which is really two different missions, one in 2016 and another in 2018. It involves cooperation between ESA and Roscosmos, with key elements contributed by NASA, and is one of the highest priority set of robotic exploration missions.

For the 2016 mission, the technology objective is entry, descent, and landing (EDL) of a payload on the surface of Mars. The science objectives are to study the Martian atmospheric trace gases and their source, and to conduct surface environment measurements. A trace gas orbiter will measure atmospheric composition and chemistry, and map subsurface water and hydrated minerals. The EDL Demonstrator Module (EDM) will demonstrate technology for landing payloads on Mars and will provide a platform to conduct environmental measurements. The EDM payload will also conduct surface measurements of temperature and pressure during the EDL process.

The nominal launch date is January, 2016, to arrive that October. ExoMars 2016 will have a soft landing at Meridiani. The lifetime of the TGO is about 7 years, the lifetime of the surface element is several sols. The mission is in the critical design review (CDR) phase, and the review team is looking at the orbital lifetime assessment. The clean room has been completed, and a new microbiological lab has been build next to it. The team will use a newly approved rapid assay procedure. There is a new bioburden accounting database, training of personnel is ongoing, and the first last-access assays on flight hardware started in April.

The 2018 mission will have more Russian involvement; the ESA contribution is primarily a rover. ExoMars 2018 will search for signs of past and present life. A drill system will be able to go 2 meters below the surface. Surface mobility will not quite be at the level of Curiosity. Roscosmos will provide the lander and some additional payload. The launch is planned for 2018, to arrive in early 2019. The mission will also be solar powered. Dr. Michael Meyer noted that it took a long time to go through Curiosity's first activities, and that time could have been reduced with more trials on Earth. The ExoMars missions might learn from that.

Regarding the operation of the drill and the sample acquisition, Dr. Kminek said that there was discussion about whether to leave a sample in the drill overnight. About 10 to 12 materials have been tested, and the drill performed well, though there were problems with very soft rock. It was decided that a sample could be out for about 5 minutes, which provides an opportunity to take a photograph. The planetary protection side set this constraint in order to avoid too much contamination.

For the 2018 mission, there has been a call issued for a landing site working group, and a call for proposals will come soon. The down-select will take place at a workshop in March, to no more than four candidates. The workshop will cover science, engineering, and planetary protection concerns. Dr. Kminek is a member of the landing site selection working group. From a planetary protection perspective, the most important thing was to agree with the Russians on the bioburden elements. Much will be carried over from the 2016 mission, including the use of facilities.

The Mars Organic Molecule Analyzer (MOMA), Raman Spectrometer (RLS), and MicrOmega imaging spectrometer are very integrated, which can make it difficult to test and validate all of the procedures. The three instruments must be able to look at samples together. MOMA is now in the middle of preliminary design review. It has been determined that MOMA cannot provide all of the models that the project requires, nor can it provide, the flight model at a time originally required by the project. Schedule discussions are ongoing. The proposed MOMA model is lower fidelity, which is another concern. There will be limits on the ability to conduct end-to-end testing of sample preparation, distribution, and analytical functions before the launch. This means that there will be no end-to-end verification of cleanliness as an integrated system. The MOMA team has provided a solution, and Dr. Kminek's office has asked for more information and refinement. After the next round of documentation comes in, his office will decide whether to have a full planetary protection review.

The inability to do end-to-end testing is a concern. He would like to see end-to-end cleanliness verification, but it is not that straightforward. He would also like to see verification that the valves and plumbing do not leak. The project has called for a RISC (Rover Instrument Steering Committee) meeting that includes the lead funding agencies.

Dr. Kminek clarified that the landing approach will include a parachute along with the thrusters. MOMA is a key element of the mission.

Adjourn for the Day

The meeting was adjourned for the day at 5:04 p.m.

Wednesday, November 13

Overview of the Day

Dr. Allen opened the meeting, reviewed some logistical issues, and discussed the revised agenda. That afternoon, PPS was to visit the SAM lab. Dr. Levy added that the schedule allowed ample time for discussion in the afternoon.

Mars 2020 Mission

Science Definition Team
Dr. Mitch Schulte, NASA Headquarters Program Scientist for Mars 2020, explained that the mission will enable investigators to build on what they have learned. NASA currently has two Mars rovers: Opportunity, which is about to celebrate its 10th anniversary, and Curiosity. Opportunity and Curiosity have enabled exploration of habitability. Investigators are now seeking signs of life. All along, there has been the goal of preparing for human exploration.

The science definition team (SDT) for Mars 2020 was stood up in January, 2013, through a competitive process. The highest priority science goal is to address questions of habitability and the potential origin and evolution of life on Mars. To accomplish this, NASA will explore an ancient site relevant to Mars' early habitability, using a variety of sophisticated measurements. The SDT was tasked with defining a 2020 rover mission to address past habitability, potential biosignature preservation, progress toward sample return, and contributed technology/HEO payloads.

Dr. Schulte provided an overview of the mission, which is expected to launch in summer of 2020 and reach Mars 8 to 9 months later. It builds on what NASA has learned from the MSL experience. For example, the EDL will be the same as that of Curiosity. The surface mission will last for 1 Mars year, the equivalent of 669 Earth days.

The SDT envisions a mission that will conduct rigorous in situ science to characterize the geologic context and history of the landing site while also doing astrobiology; enable the future by conducting sample return, paving the way for human exploration, and providing a necessary technology demonstration; and respect current budgetary realities by incorporating what has been done and using a moderate instrument suite.

Dr. Schulte next reviewed the mission objectives. Objective A is to explore an astrobiologically relevant ancient environment on Mars in order to decipher its geological processes and history, including past habitability. Dr. Schulte explained that, in this context, "ancient" implies a location where the astrobiologically relevant environment no longer exists but is preserved in the geologic record.

The recommendation is to go from large to small scales. This would involve integrating observations from orbit down to regional and eventually sub-millimeter levels. To assess habitability of the past environment, the rover must be able to characterize the geological record and should be able to detect water and its persistence, the availability of the elements critical for life, energy sources and their availability, and favorable conditions (water properties, protection from radiation, water energy, rate of burial). The SDT found that the ability to spatially correlate variations in rock composition with fine-scale structures and textures is critical.

Objective B is to assess the potential for preservation of biosignatures within the selected geological environment, and also search for potential biosignatures. Dr. Schulte described the four-step process for detecting past life on Mars. The first three steps address habitable environments and the potential for life; these can be done on Mars by the rover. The fourth step, recognition of a definitive biosignature, will probably need to be done on Earth and requires that samples be returned to Earth for complete characterization. Only a returnable cache can accomplish that step, which addresses Objective C, to demonstrate significant technical progress toward the future return of scientifically selected, well-documented samples to Earth.

There are many reasons why a sample return is necessary. For example, there are instruments that cannot be taken to Mars, and analyses must be replicated in different labs, etc. For the highest scientific return on investment for understanding Mars and addressing whether there was life, a sample return is required.

The sample return will also provide an opportunity for radiometric dating of materials. The SDT determined three attributes of a returnable cache: enough scientific value to merit return; meets planetary protection requirements; and, returnable in an engineering sense.

Objective D is to provide an opportunity for contributed HEOMD or Space Technology Mission Directorate (STMD) participation, compatible with the science payload and within the mission's payload capacity. The 2010 space policy set the goal of having humans in the vicinity of Mars by the mid-2030s. Mars 2020 will be key in the proof of concept and validation of the highest priorities needed to meet that goal: in situ resource utilization (ISR) oxygen production, an appropriate instrument suite, surface weather understanding, and biomarker detection. The HEOMD priority is the ISRU demonstration, as NASA must support performance and reliability before risking the lives of astronauts. Mars 2020 will be an excellent opportunity for synergy between science and human exploration objectives.

Dr. Schulte described the measurement capabilities needed for geology, biosignatures, and caching. Measurements or demonstrations associated with human exploration/technology would enhance the value of the mission to HEOMD, STMD, and SMD. SDT proposed two "straw" payloads that accomplish each measurement. The team also developed costs of the measurements. This led to plausible mission scenarios. Landing the rover will be key, but each parameter can be adjusted.

Mars 2020 will provide exciting opportunities for advances in reaching important scientific targets, making fine-scale measurements, recognizing potential biosignatures, collecting samples for future return, and preparing for human exploration of Mars. It was noted that a couple of potential new technologies can help reduce the landing site range. New architecture and planning will be necessary to return the cache collected by Mars 2020. Conceivably, this second mission could be launched in 2022.

Where We Are Going
Dr. Meyer explained that PSD has confidence in the SDT's work, and so has issued an AO, with proposals due in January. While hopes are high, no one is quite sure what will come in. When the reviewers see the proposals, PSD will then be able to balance the cost risks. Existing instrumentation has been tested and evaluated for cost. Some things that have not yet flown do have a development heritage. Dr. Green added that the Agency just approved the mission to enter Phase A.

Dr. Meyer said that a call went out to the science community about the potential landing site. Criteria emphasize the requirement that the field site include access to an "astrobiologically relevant ancient environment." Many potential landing sites have already been identified. In addition, access to astrobiologically relevant materials and/or unaltered igneous rocks might elevate the perceived value of a site, though that is not a requirement, as sample return elements may be more important in selecting a site.

Dr. Meyer next showed candidates for the Mars 2020 reference sites, noting that it is possible that new sites will be added to the list. His team wants to stress the system and see what is possible. Versatility is essential. Terrain-relative navigation (TRN) allows the landing rover to specifically avoid areas, like hazards, mountains, etc. The team will even be able to change sites at the last minute, when the mission is en route to Mars, though the prime landing site should be identified about a year before launch. In asking the community for site suggestions, there was a new emphasis on "special regions." At the landing site workshop planned for May 2014, PSD hopes for a vigorous debate on potential sites.

Dr. Meyer reviewed the engineering constraints and noted that NASA is looking at smaller landing ellipses. The first landing site workshop will begin a process of prioritization by scientific merit. The science community will assign a priority of high, medium, and low, ultimately leading to information about the highest priority sites and the scientific merit of each.

Discussion
Dr. Rummel asked why the workshops would discuss sites with planetary protection requirements that cannot be met. Dr. Meyer explained that he wants the science community to have the debate to identify the sites. He does not want to rule out a challenge that the community might want and that JPL would embrace. As for evaluating sites for planetary protection first, Dr. Meyer noted that a consideration that arose late for MSL last time was deliquescence. His team has just set up a science analysis group (SAG) to identify special regions on Mars and report on where there might be minerals that raise concerns. That process is just beginning.

Dr. Lindberg asked if it would make sense to look at the stressor locations and consider planetary protection at the first workshop. Dr. Meyer replied that the information for that is incomplete, and that is the reason the mission cannot have planetary protection as a consideration from the beginning. The team needs a group to tell them what to look for and worry about. He does not want planetary protection to come in late, however. This is an unusual mission that will set the science and requirements for future missions. He would like to have another SAG that helps resolve how to determine the contamination levels for the future.

Dr. Meyer added that in this case, they will bring back samples without knowing the capabilities of the instruments. There will have to be a means of measuring self-contamination. Dr. Steele said that if the investigators monitor what is going in, they can then have a baseline that they subtract from their measurements. They could have a container in addition to the sample.

Dr. Kminek raised the issue of balancing the required level of cleanliness with verification by contamination detection pre-launch. That is where cache design can either support characterization or make it very difficult. Dr. Meyer said that PSD is discussing setting up a board or group of well-known scientists with sampling expertise, and having them available for sampling questions. There are many subtleties involved. The broad science community should be involved in caching and work with the engineers. While Dr. Meyer said that he did not envision having a control (negative) container, Dr. Matt Wallace of JPL said that the team was considering all variations of canisters.

<u>Continuation of Life Detection Mission Discussion</u>
Dr. Conley stated that planetary protection is a major element of a returnable cache and the first step in sample return. The NASA policy on returning material to Earth from Mars is a “restricted Earth return.” There are also international policy guidelines that must be made into engineering policy. Culture-based experiments do not detect all life on Earth, and the same is likely true for Mars. If one organism in a sample is dead, that does not mean that all organisms from where the sample was collected, or elsewhere on Mars, are dead.

The requirements for biological contamination of Mars missions are based on a spore-growth assay, which was never intended to measure all organisms present on the spacecraft. The international community looked at the risk assessment activity done for the Viking project and decided that that level of risk should apply across the board. It is not a comprehensive protection of Mars, which would require never visiting Mars. Rather, it is an engineering metric that must be met in order to do the project. In testing sterilization methods, the heat goes from 110 to 200 degrees C.

Constraints on Mars sample return include sample containment. After the sample is on Earth, there must be an evaluation of potential biohazards. Investigators must prevent samples from being released until we understand what is in the sample and what could happen if it gets out. Canisters must be closed and stay closed until they are deliberately opened under containment. In addition, the hardware from the Mars environment must be contained so that the exterior breaks “the chain of contact.” These are based on both scientific and non-scientific considerations that lead to engineering constraints for which solutions are welcome. Many organisms on Earth can survive extreme conditions, so it is important to understand the range of possibilities. NASA should assume something is hazardous until it is proven otherwise.

At the regulatory level, there are planetary protection requirements at the multi-mission campaign level. These would apply to all flight elements, landed elements, and orbital elements. Prior experience shows that the sooner these are considered, the better the team will do in meeting the engineering constraints. If the study team wants the option to go to a special region, they should design for a special region.

COSPAR has, over decades of work, developed requirements for MSR, which ESA and NASA continue to refine. For example, the NRC recommended that samples returned from Mars should be contained and treated as potentially hazardous until proven otherwise, while the ESF clarified this as meaning to treat such samples the same as ebola and other lethal viruses. The NRC also recommends that no uncontained Martian materials should return to Earth unless sterilized, which the ESF refined in a recommendation to maintain a less than 1 in 1 million chance of release, even before it is known whether or not the sample is hazardous.

“Potentially hazardous” implies that hazards must be either destroyed or contained. This leads to questions about the means of sample sterilization. Sample containment must ensure safety on Earth, which requires determining the risk from accidental breach of containment and the possibility that some living thing in the sample could escape containment. The information from returned samples will be used to mitigate potential harm to astronauts. The NRC report 'Safe on Mars' does not preclude human exploration before sample return, but it does express a strong inclination to do robotic collection first.

Mars 2020 will cache samples to be gathered by a subsequent mission. The overall mission objective will be to search for life both in situ and, possibly, in the returning sample. The SDT report firmly concluded that the mission should not be required to target special regions. The project anticipates capturing more detailed planetary protection “daughter” requirements within the standard systems engineering tools and structures. A subtle issue is the difference between landing in a special region and taking samples in a special region. This is a science-driven mission, and the mission team will respond to the highest level science. The landing site will make a difference in characterization and implementation.

Dr. Conley next described the Category IVb requirements for Mars, from NPR 8020.12 section 5.3.2.2, emphasizing that lander systems either have specific restrictions on the biological burden detected by life-detection instruments, or are sterilized to the Viking post-baking levels. Protection from recontamination is also required. The original COSPAR language on which the restrictions are based has eliminated the phrase 'whichever are more stringent' from the two alternate implementation options, but NASA still retains that language. Dr. Conley sought PPS input on this.

Dr. Conley next reviewed policy considerations of past versus extant life. The detection of life on Mars would have significant implications for future exploration and planetary protection policy. One can argue that Viking found life on Mars, which some of the investigators still believe, but the larger scientific community chose not to believe it. The ESA ExoMars rover is targeting biomarkers of life on Mars, while the SDT report said that Mars 2020 should assess the potential for preservation of biosignatures. The question is whether there is a real difference between detecting biosignatures and biomarkers, and detecting life? What does this say about excluding the potential for extant life? And what are the implications for finding life for future mission requirements? These are not philosophical questions; they are issues that must be dealt with for Mars2020.

Dr. Steele said that a consensus on the detection of 'life' is a community-decided response to data. There must be a process to assess each of these at each point in time. Community consensus is required to determine these responses. Dr. Rummel added that the data measurement and analysis process must be run like a mission, and it must be comprehensive. Dr. Conley said that the best people to know the nature and sensitivity of life detection experiments are those who develop the experiments. If an instrument detects biomarkers, those measures should feed into planetary protection requirements.

Dr. Conley presented the Category IVB outbound requirement according to Planetary Protection Category V, restricted Earth return, which requires that subsystems of missions involved in sample acquisition, return, storage, and analysis “must be sterilized or cleaned to levels of bioburden reduction driven by the nature and sensitivity of the particular life-detection experiments driven by the life detection and biohazard assessment protocol, and a method of preventing recontamination of the sterilized subsystems and the contamination of the material to be analyzed is in place.” This requirement raises a number of questions, especially regarding the phrase “driven by the nature and sensitivity of the particular life-detection experiments.”

Life detection experiments performed on Mars material returned to Earth will require the highest level of available technology and capabilities. The conclusions drawn must be at a high level of confidence. The measurements and detection sensitivity will drive contamination limits across the entire mission. There is a process that starts with an initial analysis on the surface, then destructive analyses, followed by bulk containment requirements for wet chemistry and life retrieval/analysis. The mission will have to set contamination limits, so it is necessary to understand from the beginning what those limits must be. The issue is to avoid a false positive, or rather a real positive detection of Earth life that is not distinguishable from detection of Mars life. Instrumentation will be at least as good as what exists today. Investigators can currently detect organic material at very sensitive levels. Detection of organic material in bulk samples can attain parts-per billion-sensitivity, but it is not certain that a mission can clean to that level.

Dr. Steele put forth a scenario in which samples are collected and the investigators find organic signatures but no definitive biosignatures in what appear to be interesting samples. The cache then sits on Mars and the surface environment affects it while it sits. The cache collection will have more requirements, . as the subsequent mission has to break the chain of contact with Mars while protecting the samples. It appears that verification of actual sample cleanliness would be beyond the Mars 2020 capabilities. Dr. Conley replied that cleanliness requirements on the cache hardware would have to be verified before the launch of Mars 2020, taking into account models for recontamination by redistribution of spacecraft-associated materials during launch, cruise, and operations at Mars through final deposition of the cache.

A science working group will start meeting in January, beginning with a literature review and followed by teleconferences, a meeting with the NRC on what the study team finds, and a draft report to be delivered in May. The group is likely to be primarily scientists, with some engineers. This must be a scientifically rigorous activity.

Dr. Kminek said that there must be separate requirements regarding contamination levels and recontamination prevention. These are not the same. In addition, other government agencies will need to be involved. Dr. Conley replied that the PPS represents the initial stages of this, but that a more formal mechanism will be developed later, in the form of NRC-recommended additional oversight and input. Dr. Levy observed that this is the beginning of addressing the challenging issues of the Mars 2020 mission. The planetary protection issues will apply to it more than to any prior mission. This will place great responsibility on all participants. There must be a high level of open communication and interaction on all of these issues, more than has occurred previously, and those involved will encounter new issues. Increased communication among all parties will be crucial.

Discussion

Dr. Levy noted that Dr. Conley had mentioned the words “whichever are more stringent” in a requirement that NASA has maintained and that COSPAR has dropped. The process for changing this wording involves two steps. First, PPS determines that it is not necessary, and it is then struck during the next round of edits to the requirements documents.

Discussion turned to the following text from Dr. Conley’s presentation:
NPR 8020.12 section 5.3.2.2:

PP Category IVb. Lander systems designed to investigate extant Martian life shall comply with all of the requirements of PP Category IVa and also with one of the following requirements:
EITHER
a. The entire landed system is restricted to a surface biological burden level of 30 spores (see 5.3.2.4) or to levels of biological burden reduction driven by the nature and sensitivity of the particular life-detection experiments, whichever are more stringent, and protected from recontamination.*
OR
b. The subsystems which are involved in the acquisition, delivery, and analysis of samples used for life detection are sterilized to these levels. Methods for preventing recontamination of the sterilized subsystems and preventing contamination of the material to be analyzed is provided.

Dr. Conley explained that point “a” applies to living organisms, which would be detected in culture or metabolism-based measurements. The “b” option addresses whatever would be detected by a particular life detection instrument. COSPAR asked why investigators would be concerned about live or dead bodies if they cannot see them in first place. This is explicitly in the context of life detection experiments.

Dr. Steele had an issue with the word “experiment,” which he did not see as applicable in life detection. Dr. Conley agreed that she would like to change that wording, which was an artifact of the Viking missions. “Investigation” would be better. Dr. Lindberg said that it should remain in order to be consistent with COSPAR, but Dr. Kminek reported that ESA had changed it, and Dr. Meyer thought that being consistent with COSPAR did not require repeating its wording verbatim. Dr. Kminek explained, and Dr. Conley agreed, that the term “life detection investigation” was the preferred replacement term. It would encompass sample return. It also includes an “element of faith” that investigators can predict or set appropriate levels to detect life. Dr. Michel Viso observed that it is not possible to clean everything to perfection, including the returning spacecraft. Dr. Conley explained that detection abilities exceed the capacity to clean hardware such that the current best-available laboratory techniques could detect it. The cleanliness requirements on return samples and hardware will most likely have to be based on the limitations of pre-launch verification capabilities, rather than final detection sensitivity.

Dr. Levy asked the Subcommittee if there were any reason not to make the change. Dr. Karen Buxbaum said it was not clear how removing the language would affect the process of setting the requirements. Dr. Conley said that an instrument that detects organic compounds at a moderate level would only have to be cleaned to that level.

Dr. Levy asked if there were consensus on changing the language. It was agreed that this could be conveyed to the PPO (Dr. Conley) without going through other channels. In the absence of objections, PPS agreed to remove the words “whichever are more stringent” in order to be consistent with COSPAR. That change was to be officially communicated to Dr. Conley.

Dr. Levy next raised the issue of how to think of extant life and the Mars 2020 mission. Dr. Conley said that there is some degree of logic in assuming that if investigators detect a biosignature for ancient life, they can infer the continuation of life. In other words, if they find an indication of life, they cannot assume that it is no longer present. For Mars, investigators cannot assume that life is nonexistent in those areas outside that in which the biosignature is found. For planetary protection purposes, the best arbiter of a biomarker detection experiment is the investigation team. Investigators must accept the instrument detection limits. If they find something, they have measured that they have found it.

Dr. Steele explained that the SDT grappled with “extinct” and “extant.” The distinction is one of interpretation. The investigator makes the measurement, then interprets the data based on probabilities. The SDT thought that extinct life was the most probable form of life to detect. This would go back to when Mars was warmer and wetter. It became an exercise in maximizing the chances of finding extinct life. There must be a plan for extant life, however, as part of planetary protection. Dr. Lindberg asked if it might be possible to have an in situ instrument designed to identify the biosignatures of extinct life that could also identify extant life. Dr. Steele said that this is possible, but biosignatures of extant life are all potential unless the life forms come right up to the instrument and wave at it.

Dr. Meyer explained that from the Mars Program point of view, an experiment looking for extant life is not as conclusive as one looking for extinct life. It is therefore unlikely that NASA would send such a payload, as it would be wasted. Once the instruments are developed, the distinction does not really matter. Dr. Kminek thought there was too much similarity assumed between Earth and Mars. He also believed that the science community has the right interpretation of how to deal with extinct/extant, and that from the planetary protection standpoint, there should be just one term. Investigations looking for extinct biosignatures will possibly see extant life, but not vice versa.

When the suggestion was made to remove the word “extant” from the conversation, Dr. Colleen Cavanaugh objected, saying that such a change would remove the inspiration. Dr. Conley suggested a word change of “could detect” instead of “designed to detect.” The SAM instrument could detect Earth organisms that were put into the instrument, for example.

The ExoMars team has extensively tested materials to see how they might affect measurements. There was discussion of the off-gassing properties of Teflon, which can affect detection. Dr. Meyer said that the system for acquisition and handling is not yet settled, as PSD is still waiting to see what is proposed. The expectation is that whatever is cached does not see the light of day. It is encapsulated and goes into another container. If investigators want to know something about the sample before it is cached, they would have to take a second sample to analyze. Dr. Levy noted that the general sense of the Subcommittee seemed to be against changing the word “extant.”

Dr. Levy next explained that the organizational structure of the NAC was being reconsidered, which could affect the PPS reporting line and the location of the planetary protection function within NASA. Dr. Allen was on the team looking at the NAC structure; she reported that the team recognized that PPS is different from the other advisory committees and probably should not be under any of the directorates it is trying to advise. That was addressed in the reorganization proposals, as was where the PPO resides in terms of reporting within the Agency. There was still time to make a recommendation regarding the placement of the PPO. Dr. Levy said that he and Dr. Lindberg would work on a draft recommendation to circulate it to the Subcommittee.

Dr. Steele added that regarding Mars 2020, what is known about Mars is based on MSL. He wondered if there is funding for the new in situ instruments and the development of sterilization techniques. There should be an ongoing dialogue about this from a planetary protection standpoint. Dr. Levy said that Mars 2020 should have planetary protection involved throughout, and intimately. Dr. Meyer said that he has encouraged Dr. Conley’s involvement, including participation in biweekly teleconferences. Dr. Levy wanted to see a coherent compilation of the work that has been going on, so that PPS can have a clear picture of what is being spent and by which NASA elements. Specifically, for the next meeting, he wanted to know what is being spent by JPL, what is being done at the behest of the PPO, and what the role of the PPO is at NASA.

He also sought more about the impact on sterilization. Dr. Meyer mentioned the sterilization of the drill bit by the perchlorate on Mars. Dr. Kminek said that the heat of reentering the atmosphere does most cleaning of the vehicle. Dr. Conley pointed out that the requirements for Mars missions are based on the Viking requirements, which led to the current standards. The re-evaluation of that context is important. She would love to have the resources to speak to the science community about these issues.

Dr. Teplitz asked when the asteroid redirect mission will address planetary protection. Dr. Green answered that the asteroid must be identified first. Dr. Conley said that planetary protection is based on the type of asteroid, but that most near-Earth asteroids are likely to be considered Category II outbound and 'Unrestricted Earth Return', so there would be no planetary protection restrictions on the astronaut mission. Regarding human exploration and interaction with the asteroid, there are still considerations about the health effects of exposure to the asteroid material. It would be very useful to understand the consequences of exposure to non-living asteroid materials, and collect data on the interactions with the astronaut microbiome and spacecraft-associated microbial populations. Having data from asteroid exposures, which do not carry viable organisms, would provide a baseline for comparison when an astronaut becomes ill on the way back from Mars. If all of the microbial alterations have been observed after exposure to non-living asteroid material, this could increase confidence that the illness was not due to some martian microbe. . Planetary protection will be involved in the evaluation of the candidate asteroids, but they must be identified first. In addition, they will likely be in Earth's vicinity and their material will already be here.

Dr. Levy informed the Subcommittee that he was urged by the NAC Science Committee chair to look at the possibility that astronauts in space develop gut microbes that are pathogenic to people on Earth. He declined to take that up. He said that, first, regardless of the merit, this was outside of the PPS purview. Secondly, if anyone is to take up the issue, they should have medical expertise. He wanted the Subcommittee members to know about this conversation, and to confirm that the members were satisfied with his refusal.

Adjourn

The meeting was adjourned at 3:06 p.m.

Appendix A
Attendees

Planetary Protection Subcommittee Members
Eugene Levy, *Chair Planetary Protection Subcommittee*, Rice University
Catharine Conley, *Planetary Protection Officer*, NASA HQ
Colleen Cavanaugh, Harvard University
Joanne Gabrynowicz, University of Mississippi
Victoria Hipkin, Canadian Space Agency
Gerhard Kminek, European Space Agency
Robert Lindberg, *Deputy Chair PPS*, University of Virginia
John Rummel, East Carolina University
Andrew Steele, Carnegie Institution
Vigdor Teplitz, Department of State
Michel Viso, CNES/DSP/EU
Gale Allen, *PPS Executive Secretary*, NASA HQ

NASA Attendees
Barbara Adde, NASA HQ
T. Jens Feeley, NASA HQ
Robin Frank, NASA GSFC
James Green, NASA HQ PSD
James Johnson, NASA JSC/HQ
Paul Mahaffey, NASA GSFC
Michael Meyer, NASA HQ SMD
Michael New, NASA HQ SMD
Betsy Pugel, NASA HQ
Mitch Schulte, NASA HQ
Bette Siegel, NASA HQ
J. Andy Spry, NASA JPL
Matt Wallace, NASA JPL

Non-NASA Attendees
Jon Calomiris, Sotiria Science
Elizabeth Sheley, Zantech
Perry Stabekis, Gentex

WebEx/Telephone
Carlton Allen, NASA JSC
Karen Buxbaum, NASA JPL
Kelvin Coleman, Federal Aviation Administration
Robin Frank, NASA HQ
Marc Fries, NASA JSC
Diedre Healey, NASA HQ
Melissa Jones, NASA JPL
Richard Sikorski, NASA GSFC
John Simmonds, NASA JPL
Ellen Stofan, NASA HQ
George Tahu, NASA HQ

Appendix B
NAC PPS Subcommittee Membership

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

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

Penny Boston
Department of Earth and Environmental Science
New Mexico Tech

Colleen Cavanaugh
Biological Laboratories
Harvard University

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

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

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

Robert Lindberg (Vice Chair)
University of Virginia

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

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

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

John D. Rummel
Professor, Biology
East Carolina University

Andrew Steele
Geophysical Laboratory
Carnegie Institution of Washington

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

Victoria Hipkin
Program Scientist, Planetary Exploration
Canadian Space Agency

Gerhard Kminek
Planetary Protection Officer
European Space Agency

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

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

Subcommittee Administrative Support:
Ms. Ann Delo
Science Mission Directorate
NASA Headquarters

Appendix C
Presentations

1. NASA's Planetary Science Program Overview, *James Green*
2. Planetary Protection at NASA: Overview and Status, *Catharine Conley*
3. Planetary Protection for Human Exploration Missions, *Bette Siegel*
4. Planetary Protection at ESA: Issues & Status, *Gerhard Kminek*
5. Curiosity, *Paul Mahaffey*
6. The ExoMars Programme, *Gerhard Kminek*
7. Final Report of the 2020 Mars Rover Science Definition Team (SDT), *Mitch Schulte*
8. Landing Sites, *Michael Meyer*
9. Planetary Protection Considerations For Mars 2020, *Catharine Conley*

Appendix D
Planetary Protection Subcommittee Agenda
Goddard Space Flight Center
8800 Greenbelt Road, Greenbelt, MD 20771
November 12-13, 2013

Nov 12, 2013 GSFC Building 28 (Room E210)

9:00 a.m.	Welcome, Orientation, Introductions	G. Allen and TBD, HQ
9:10 a.m.	Words from the Chair	Eugene Levy, Rice Univ.
9:30 a.m.	Remarks from NASA Chief Scientist	E. Stofan
9:45 a.m.	Planetary Protection at NASA: Issues and Status	C. Conley, PPO/HQ
10:30 a.m.	Break	
10:45 a.m.	HEO and Planetary Protection	C. Conley/B. Siegel, HEO
11:15 a.m.	Planetary Protection at ESA: Issues and Status	G. Kminek, ESA
12:00 noon	Lunch	
1:15 p.m.	Planetary Science Division Status	J. Green
2:30 p.m.	S&MA Technical Authority	D. Healey
3:00 p.m.	Discussion	E. Levy/G. Allen
3:15 p.m.	Break	
3:30 p.m.	SAM presentation	P. Mahaffy
4:00 pm	ExoMars/MOMA presentation	G. Kminek
4:45 p.m.	Discussion	E. Levy/G. Allen
5:00 p.m.	Adjourn for the Day	

November 13, GSFC Building 21 (Rooms 183A and B)

8:30 a.m.	Overview of the Day	E. Levy/G. Allen
8:45 a.m.	Mars 2020 Mission - Science Definition Team - Where we are going	C. Conley/all
10:00 a.m.	Break	
10:15 a.m.	Continuation of life detection mission discussion - Intro to life detection mission workshop - How to organize study group? - NRC meeting of experts? Other?	E Levy/ C Conley
11:15 a.m.	Discussion	E. Levy/G. Allen

11:30 a.m.	Continuation of life detection mission discussion - Process to nominate participants - Dates? - Other	E. Levy/C. Conley
12:00 noon	Lunch	
1:15 p.m.	Recommendations; next meeting dates	E. Levy/G. Allen
1:30 p.m.	Recap	E. Levy/G. Allen
1:45 p.m.	Tour Facilities	R. Christensen
4:00 p.m.	Adjourn	