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John C. Stennis Space Center
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MEETING REPORT

David McComas, Chair

Elaine Denning, Executive Secretary

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Welcome and Introduction

Ms. Elaine Denning, Executive Secretary of the NAC Science Committee (SC), called the committee to order and explained the FACA rules for the membership, including recusal rules governing Special Government Employees. Dr. David McComas, SC Chair, noted that Dr. Robert Lindberg would be representing Dr. Eugene Levy for the meeting, and welcomed new member Dr. James Green, an astrophysicist, to the committee.

International and Domestic Travel and Collaboration

Dr. McComas explained that the briefing on this topic arose from prior discussion with a number of people, including Dr. John Grunsfeld, Associate Administrator (AA) of the Science Mission Directorate (SMD), regarding how NASA has interpreted travel guidelines handed down from the Office of Management and Budget (OMB).

Mr. Dan Woods presented a status of NASA's latest policy travel regulations. The policy's main objective is to enable scientists to do science in part through ensuring that they can participate in critical meetings and conferences. Federal travel restrictions originated in OMB Memo-12-12 that reduced travel budgets by 30% from the 2010 level. The memo also increased scrutiny on conferences, requiring that any conference costing over $100K obtain approval from the NASA Deputy Administrator, while any conference over $500K is prohibited unless waived by the NASA Administrator; this memorandum is still in effect today [1/12/2015]. Administrator Bolden has approved all conferences over $500K, notably for the American Geophysical Union (AGU), recognizing its importance to SMD and the NASA centers.

Congress now imposes reporting requirements on conferences costing over $20K quarterly (Public Law passed in 2008). NASA is now providing annual reports for Congress and OMB on conferences costing over $100K annually. There is a statutory limit of 50 federal employees at any foreign conference (Public Law passed in 2011). In 2013, the Agency received a memo from OMB delineating new restrictions on both travel and conferences during sequestration. NASA has spent much time reacting to these restrictions over the last two years. The situation has improved since that time; for instance, it is no longer necessary to consult with the Chief Financial Officer (CFO) for conferences under $75K; and there is no longer a need to obtain waivers for domestic conference attendance above 50 attendees. NASA implementation of these restrictions is summarized in NASA Interim Directive (NID) 9700.1.

Currently, NASA is still subject to spending limits. Conference spending over $100K must be approved by the Deputy Administrator; conferences over $500K are still prohibited unless waived by the Administrator. Conference reporting requirements remain in place, necessitating

extra work by support staff to enable internal controls and reporting. Foreign conference attendance limits remain in place, but the sum now includes civil servants and contractors in the count. Reduced travel spending budgets remain in place (FY10 budget level minus 30%), but Mr. Woods stated that he considers the situation to be manageable. Mr. Woods reported that at one point, the centers had pulled back so severely that Headquarters was compelled to direct centers to spend their allocations. This situation has since been corrected.

Each conference is assigned a lead center or NASA HQ office to file an estimate of total spending and justification as directed by NASA Form (NF) 1784. No approval is required for any conference that is not sponsored by NASA, as long as it is not over $75K. If total spending is constrained, then attendance is limited, which thus far has been rare. In those instances, each center receives an allotment based on demand, and has internal processes for approving attendance. Total spending includes civil servants and contractors, but does not include grants to external scientists.

The Science Committee noted that the limitations seemed to have been intended for civil servant travel only and inquired who made the determination to include contractors in conference approval and reporting. Mr. Woods explained that the NASA CFO had formulated these spending guidelines, which had been created in consultation with members of the NASA Executive Council, members of which include the Chief Scientist and Chief Engineer. The Executive Council has also been involved in promoting relaxation of some restrictions. Mr. Woods took an action to more explicitly identify who had interpreted the OMB guidance, especially concerning which groups were covered by the "50 attendee" limitation.

Mr. William Lightsey addressed NASA's recently adopted pilot approach to the conference approval process, which is being implemented by the Astrophysics Division (APD), following a meeting of center leaders that addressed late approvals, which had been driving up costs. Another concern had been unhappiness with some center allocations. NASA is now asking centers to estimate conference attendance a year in advance. Challenges to this approach include the fact that approvers must approve a non-urgent submission. Mr. Woods addressed local conference attendees being subject to the same restrictions imposed on other attendees even though the cost of their attendance is substantially less. It recently has been decided that when SMD is the lead center for a conference, it will exempt local attendees when determining center allocations (for example, when the AGU conference was held in San Francisco in December, Ames-based attendees were exempted).

Mr. Woods addressed committee concerns about interpretation of the guidance. Some members felt that the centers are applying more conservative restrictions on the process than SMD; and that this impacts anyone trying to attend any conference managed by a center. Mr. Woods felt

that such conservatism may be rooted in that fact that a center must prioritize programmatic and travel budgets. Dr. Janet Luhmann commented that the costs of tracking travel may be prohibitive, and that the process could use a sanity check. Mr. Woods acknowledged that it is a very time-consuming, intense administrative process. Dr. Carlé Pieters questioned why large conferences were off limits. Dr. Harlan Spence felt that management at Headquarters seemed to be more lenient toward travel, and that there is no uniformity of approach at the centers; NASA lacks full awareness as to how much the community is churning with the issue. Dr. McComas commented that the SC would like to understand the latitude NASA has to interpret these guidelines.

SMD/STMD Technology Infusion Cooperation

Dr. Mike Seablom, Chief Technologist for SMD, addressed a recommendation from the NAC that the Space Technology Mission Directorate (STMD) and SMD AAs establish new policies and procedures that would enable new technology infusion in small- to medium-class missions. Prior to the NAC recommendation, Dr. Seablom established a Technology Federation to serve as a communication infrastructure between the science subdivisions, and he works with these staff on a daily basis to understand technology needs. Dr. Seablom also serves as the primary lead in SMD that communicates with STMD, and he reports directly to SMD senior management.

NASA's overall strategy for technology infusion is based on investments in three areas - Continuous Improvement, Operational Transformation, and Revolutionary Improvement, which respectively address technologies that are generally 1) low-cost, low-to-medium payoff; 2) substantial new products/capabilities, high-value, moderately to widely available; and 3) high-cost and high-risk that are potentially high payoff in the long term. There is good overlap with the commercial off-the-shelf technologies (COTS), SMD Technology Investment, and Science and Technology Mission Directorate (STMD) Technology Investment programs.

Dr. Seablom cited the Earth Science Division (ESD) mission, Soil Moisture Active Passive (SMAP), as a good example of how sustained investments yield results over time. SMAP was conceived in 1998, transforming eventually into a Tier 1 mission that will be launched later in 2015. Within the Technology Infusion call in Discovery 2014, there are a number of technology investments being offered with incentives (worth $5-30M), such as xenon thruster, deep space optical communications, heat shield, and a deep space atomic clock. The risk associated with using these incentivized technologies will not impact proposal evaluations. The selection process is going forward.

Both the Astrophysics Division (APD) and the Heliophysics Division (HPD) have program elements set aside for technology infusion (the Astrophysics Research and Analysis Program, the Strategic Astrophysics Technology Program, the Heliophysics Low-Cost Access to Space, etc.).

The Planetary Science Division (PSD) has established the Picasso and Matisse programs for low TRL technologies. ESD has four large programs for technology investments, including an Instrument Incubator Program. Technology advancement through SMD suborbital programs is well represented in the Advanced Composition Explorer (ACE), Solar Heliophysics Observatory (OHO), and the Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI). SMD also maintains an ongoing partnership with STMD in developing a coronagraph for the APD's WFIRST mission. Small satellites and CubeSats have seen exponential growth in recent years; more than 115 CubeSats were planned last year. Within SMD, all divisions are investing now in CubeSat opportunities, working directly with the Human Exploration and Operations Mission Directorate (HEOMD) to ensure launch capability.

A good example of alternative measurement strategies, the Earth Venture Class series of missions, was created in response to a National Research Council (NRC) Decadal Survey recommendation. The Venture Class mission, Cyclone Global Navigation Satellite System (CYGNSS), will use a constellation of eight spacecraft to measure ocean surface winds.

There are roughly 12 technology programs spread across the four divisions of SMD, representing a total allocation of $20-30M, which does not include other directed technology investments. Dr. Paul Hertz interjected, stating that based on his calculations several years ago, 10-15% of SMD total budget is actually given over to technology development, a sum of over $500M per year; he stated that NASA spends tens of millions of dollars on technology investments in APD alone. Dr. McComas requested a breakdown of technology monies. Dr. Seablom agreed to respond with a better summation.

Dr. McComas addressed NASA's response to the committee's recommendation on having the SMD and STMD AAs engage with one another. Dr. Seablom felt unsure precisely what the SC was looking for - a set number of projects with STMD? Dr. McComas clarified that the SC was only asking for a review of existing policies and procedures. Dr. Seablom felt that the establishment of the Technology Federation was sufficient and didn't think new formal policies and procedures were necessary. Dr. Luhmann suggested that perhaps the target should be the selection process, especially where the issues of risk and readiness come up in the decision-making process. Dr. Hertz noted that at the AA level, there is vigorous discussion of whether SMD will accept the risk of overrunning cost caps to accommodate technology infusion, versus maintaining a cadence of missions. Dr. Green commented that the community fears incorporating any technologies into proposals that might increase science returns because there are too risky. Small mission proposals are being designed around avoiding risk rather than maximizing scientific return. Researchers are afraid to propose ideas because "they can't fly unless they have flown." Dr. Hertz felt that the community perception was unwarranted—Discovery and Explorer are flying new technologies—perhaps the community misunderstands

the policy. The SC can help the community understand this by clarifying the technology maturation cycle. Dr. Green countered that the comments and debriefs contained in losing proposals are fueling some of the perception, he gave an example of proposed technology being rejected by an industry partner because of a prior rejection of a previous proposal; there is now a book of negative comments driving the problem. Dr. Hertz felt that the issue was amenable to discussion.

Research and Analysis Two-Step Process

Dr. Max Bernstein gave an overview on a recently adopted, and partially evaluated, two-step process for the SMD Research and Analysis (R&A) program. Generally, SMD has rarely required notices of intent (NOIs) for research; only the ESD Land Cover/Land Use Change Research Opportunities in Space and Earth Sciences (ROSES) call had used a two-step process in the past. In 2011, declining selection rates prompted a change within SMD to experiment with a two-step proposal process. At the same time, NSF's Biology Division adopted a two-step process, in which they would allow one-half of approved proposers to progress to step two. The concept of a two-step submission seemed to have promise for improving the selection rate and making the selection process more efficient, while selecting the best research. NASA used a compromise approach for the 2012 ROSES Cassini Data Analysis programs. This approach required three-page Step 1 proposals, but allowed discouraged proposers to submit Step 2s. Single mail-in reviews of the Step 1 proposals were then compared with peer review panel evaluations of the full Step 2 proposals. This particular call resulted in only one proposal that was highly rated at Step 2, yet would have been discouraged at Step 1; this outcome was somewhat troubling to Dr. Bernstein. In 2013, HPD Supporting Research program used a two-step program, receiving 301 Step 1 proposals, out of which only 12 were discouraged. All 294 others were invited to proceed. For the Guest Investigator (GI) program, only 73 of 174 Step 1s were encouraged, and only 83 submitted Step 2s; 27% were selected. None of the proposals discouraged at Step 1 were selected for funding at Step 2, thus the evaluation of the Step 1 proposals seemed a good predictor of success. In the 2014 Heliophysics GI program, 95/117 proposals were encouraged and 26/90 were selected. In the Heliophysics Supporting Research program, 170/338 Step 1s were encouraged and 221 Step 2 proposals were submitted (no decision yet). Dr. Bernstein felt that the approach of merely discouraging seems adequate, in that one is not completely barring proposers; he was not comfortable with the more draconian approach of NSF of barring 50% of proposers after Step 1. He also felt it was also helpful for proposers to get detailed comments.

The PSD research program was restructured in 2014, with core programs being replaced with new calls that aligned with PSD goals (Emerging Worlds, Habitable Worlds, Solar System Workings) to focus more on process. At present, ROSES calls for proposals in PSD, some in APD, one in ESD and the Exoplanet Research Program, are using a version of the two-step

process. Most require a brief, one-page statement of the research planned. Asked by Dr. Running who makes the decision about using the two-step process, Dr. Bernstein responded that the Division Director makes the decision. In ESD, the responsibility for the decision goes to Dr. Jack Kaye. Dr. Douglas Duncan commented that proposers to Education at NSF receive a fair amount of coaching before submission.

Dr. Running expressed support for the two-step proposal regimen. Dr. Green didn't see the value of such a structure unless there was a real cut made at step one. Dr. Luhmann felt it premature to judge outcomes. Dr. Spence commended NASA for reaching out to NSF, adding that its Geosciences division had adopted the same structure with a different outcome. NSF's Astronomy and Astrophysics Advisory Committee (AAAC) has raised a task force to examine funding rates in astronomy and to determine what if anything can be done about it; the basic problem is that are too many mouths to feed. Dr. Hagan felt that it would be interesting, at the end of the Heliophysics selection, to see how many people who were not encouraged were actually selected in Step 2. Dr. Luhmann recommended considering a UK model for funding research, in which people are funded for their full salary and a number of projects. Dr. McComas worried that a limited base of knowledge on the part of some reviewers in the two-step process could severely funnel down the eventual choices. Dr. Lindberg commented that the issue is driven by the acceptance rate, and that the critical question will be how the rates stack up. Drs. Green and Luhmann were tasked to develop a preliminary statement on the subject, while recognizing that the issue is not ready for a finding/recommendation.

Public Comment Period

Mr. Josh Shiode of the American Astronomical Society asked for further clarification on NASA's travel policies. Dr. Lightsey addressed the question, explaining that large meetings at Headquarters are approved on the basis of broad attendance, and smaller meetings are covered by the centers that will have the largest attendance. Mr. Woods added that there is a Congressional requirement to report on conferences costing $20K or higher, and that this information is collected after every event and posted on a NASA website, or provided directly to reviewers.

Discussion/Findings and Recommendations

The subcommittee began a discussion of findings-worthy issues. Addressing travel restrictions, Dr. Luhmann felt it would be nice to know about costs involved in the accounting and tracking of travel, to determine whether it is a worthwhile expenditure. Thus far, it sounds as if travel policy is neither well managed nor well understood. Dr. Spence commented that an over-interpretation of language may complicate the issue, given the dramatic difference in how agencies are responding to the directive; it would be valuable to have a more uniform approach, but not necessarily the most conservative approach. Dr. McComas noted that if there is any way

NASA can interpret guidelines without added layers, it should be in the best interest of the science community. PIs spend their dollars most efficiently on missions. Perhaps it would be useful to explore the notion of whether NASA should reconsider the inclusion of contractors in head counts for conference travel. Dr. McComas proposed a finding on the contractor inclusion issue, heard general agreement, and asked Drs. Peterson and Spence to write preliminary language. Mr. Woods felt it would be helpful for the committee to look at both scope (should contractors be in or out?) and process, as NASA must implement a process to deal with the OMB language.

As to the recurring issue of technology infusion at NASA, Dr. Green felt that NASA had interpreted the SC recommendation as code for unhappiness with the Discovery and Explorer programs. Dr. McComas, noting he would be discussing this further with the NAC, asked for specific follow-up comments. Dr. Duncan observed that developing parallel technologies is a common strategy to infuse new technologies - it's a specific problem if industry is not doing this. Dr. Green suggested providing a clarification on risk mitigation proposals and risk assessment in the Discovery and Explorer programs. Dr. Luhmann suggested a specific statement on how to resolve the inherent conflict between cost risk and technology risk. Dr. Lindberg commented that the source selection team never gets to see the upside of the technology not proposed. Dr. Green felt that the current community perception was that all risk is unacceptable - if that is not the case, NASA should clarify this. Dr. McComas proposed that the committee ask two questions -- on acceptable risk versus the size and type of mission, and an approximate accounting of technology investment. Dr. McComas asked members to send specific technology inquiries to himself or Ms. Denning so carefully worded questions could be developed.

Dr. Running asked for further discussion of the two-step proposal process, given that there was clear agreement that there is some threshold (below a 30% acceptance rate) that triggers concerns in the community. There were varying degrees of agreement in the committee on this notion. There also was discussion of what feedback was given to the proposer, including for the purpose of improving a proposal. The recommendation was made that proposers discouraged in the first round be told that this information is not shared with reviewers in a next round. Dr. McComas tabled the discussion for the interim, and asked that the chairs discuss the proposal structures with their subcommittees. An action was proposed to consolidate subcommittee findings on the issue, to be brought forward to the NAC at a later time.

Stennis Space Center Presentation

Mr. Jerry Cook, Deputy Director at Stennis, gave a brief presentation on Center activities.

SC/HEOC Joint Meeting

The Science Committee held a joint session with the Human Exploration Operations Committee

(HEOC), which advises NASA's Human Exploration and Operations Mission Directorate.

Opening Remarks

Dr. Bette Siegel, Executive Secretary of the HEOC, welcomed participants to the meeting. Ms. Denning made brief opening remarks. Dr. McComas welcomed Dr. Richard Gilbrech, Director of Stennis Space Center, who subsequently gave a briefing on the center.

Welcome to NASA Stennis Space Center

Dr. Gilbrech provided an introduction to the center for the benefit of committee members.

Overview Presentation of HEOMD/SMD Joint Activities

HEOC Chair, Mr. Kenneth Bowersox, opened with remarks describing the function of the joint committee activities, which is to assess the state of interaction and cooperation between the human space flight and robotic science missions. Dr. John Grunsfeld addressed the joint session via videoconference from Headquarters on the current state of joint HEOMD/SMD activities. In his view, most of what is done at NASA is done in the service of science. The lunar landing, for instance, was driven by science. The first NASA-launched spacecraft, Explorer 1, was a science experiment. There was much debate initially about the function of NASA, but the 1958 Space Act clearly contained elements of science and exploration, without explicitly mentioning human space flight. However, human space flight took on a predominant role with JFK's call for a lunar landing. During NASA's formative years, Administrator James Webb recognized the need to transform NASA into a scientific and engineering enterprise, in order to support its objectives. Today, NASA science is interconnected and is poised to answer fundamental questions— are we alone in the universe? Is life sustainable on Earth? All of this science is a human enterprise. The four science mission directorates are convenient budget bins, but with artificial boundaries. Researchers must minimize these boundaries and work toward common goals. HEOMD and SMD meet in order to determine how science drives exploration and to determine what questions space scientists are uniquely equipped to answer. As the Agency has transitioned from Apollo to Shuttle to the International Space Station (ISS), NASA has been effective in leveraging human flight missions to support science. Present day joint activities shared between SMD and HEOMD include science instruments flown on ISS, the Mars 2020 mission, the Asteroid Redirect Mission (ARM), space navigation and communication, study of the radiation environment, and possible satellite servicing.

A joint SMD/HEOMD instrument mission, RapidScat, was recently launched to ISS, which looks at radiation scatter from the ocean surface to measure ocean surface winds. The ISS perspective provides wide coverage of Earth areas that are not available from polar satellite views. Another joint mission is the Cloud Aerosol Transport System (CATS), a LIDAR (Light Detection and Ranging) instrument that measures atmospheric aerosols and clouds.

Astrophysical science experiments on ISS include the present Alpha Magnetic Spectrometer (AMS) (cosmic ray data) and the future Neutron Star Interior Composition Explorer (NICER), a large area detector that will obtain precise data on neutron star interiors and "star quakes." The Cosmic Ray Energetics and Mass (CREAM) experiment will also launch to ISS later in 2015. The Lunar Reconnaissance Orbiter (LRO) is another joint mission that has collected high-resolution imagery of the lunar surface that can be compared to images taken in the 1960s, which among other things has been helping to determine crater ages more precisely.

Current and future Mars missions will address questions about the radiation environment affecting both spacecraft and potential human exploration. The Phoenix lander, Mars descent imager, and Curiosity rover have answered many questions about the Mars surface and environment. The Mars program is now ready to move to the next step with the Mars 2020 mission, which is being designed to seek ancient signs of life, and to capture and cache samples for future return. The 2020 instruments include Mars Oxygen In-situ resource utilization Experiment (MOXIE), which will extract oxygen catalytically from Martian atmospheric gases; the Mars Environmental Dynamics Analyzer (MEDA), an enhanced surface weather station; the Radar Imager for Mars' Subsurface Exploration (RIMFAX) antenna, which will provide data about subsurface features, as well as imagers and mineralogy experiments. Three payloads on the Mars 2020 mission will address strategic knowledge gaps (SKGs) for human exploration, including those involving Mars Entry, Descent and Landing Instrument (MEDLI) and heat shield designs. Mars 2020 site selection workshops will be held over the next few years. SMD's Solar System Exploration Research Virtual Institute (SSERVI) is addressing many issues such as dust, radiation, and habitat; research teams represent much crossover of disciplines. The most interesting places on Mars for human exploration will likely contain water (e.g. potable water, sources for oxygen extraction and fuel extraction, etc). Where there is water on Earth, there almost always is life. Therefore, Mars missions also must deal with planetary protection restrictions in determining how to avoid contamination of Mars, as well as Earth, in any sample return efforts. In March, a workshop on human extraterrestrial missions will be held at Ames Research Center to illuminate the path forward.

Space Communications and Navigation (SCaN), run by HEOMD, provides services and critical capabilities to all missions and spacecraft. SCaN's Goldstone radar is tracking the Mercury Surface, Space Environment, Geochemistry, and Ranging (MESSENGER) mission at Mercury, the Mars Reconnaissance Orbiter (MRO) and the Indian Space Research Organisation's Mars mission, the Mars Orbiter Mission (MOM). SCaN currently supports 70 active spacecraft for SMD. SCaN technology development was also involved in the recent Lunar Atmosphere and Dust Environment Explorer (LADEE) mission. Astromaterials curation and ARM are cross-directorate activities, as are space radiation characterization efforts such as the Space Radiation Working Group. HEOMD also supports SMD through the Launch Services Program.

Mr. Craig Tupper addressed the budgetary aspects of SMD/HEOMD collaboration in terms of what each directorate/division contributes to its joint activities. About $600M per year is contributed through SMD, and roughly $800M from HEOMD.

Dr. Stephen "Pat" Condon of the HEOMC asked how his committee might communicate these exciting joint activities to the general public and members of Congress. Dr. Grunsfeld cited well-attended Lunch and Learn talks at Congress that concern Mars activities, as well as the utility of many external organizations, such as the Planetary Society that can play an advocacy role that NASA cannot. His view was that the Agency could do more on the public engagement level; current efforts such as the Desert RATS (Desert Research And Technology Studies) program are more appealing to the science-oriented population. However, it should be possible to frame the Mars campaign in a more publicly appealing way. Dr. Duncan suggested that NASA cooperate with artists, as they have a compelling way to tell the story of science. Dr. Grunsfeld mentioned that NASA did consult on the films Interstellar and Gravity. Dr. Hagan commented that there is really a difference between physical conditions on ISS and transit to Mars, and that NASA must be careful not to oversimplify the (radiation) problem. Dr. Luhmann noted that humans are very interested in Near Earth Objects (NEOs), and asked whether this topic was being overlooked—can more be done to revisit the idea of a precursor mission that would fill in the gaps? Dr. Grunsfeld pointed to budget challenges that hinder the implementation of Decadal Survey missions, but NASA has been able to use national priorities to overcome some of these challenges. In the case of NEOs, SMD has a specific budget line for characterizing potentially hazardous objects. OSIRIS-ReX is a competed SMD mission investigating the asteroid Bennu, for example. The law known as the Brown Act directed NASA to identify potentially hazardous objects that are 140m + in diameter, but to date there has not been a specific appropriation to allow NASA to do this.

Dr. Spence felt that the LRO mission was an excellent example of synergy between HEO and SMD, the impetus for which came through Mike Wargo, and asked if there was someone equally dedicated at SMD. Dr. Grunsfeld responded that everyone in SMD is dedicated to similar cooperative efforts; the division is attempting to replicate the LRO model with the Mars 2020 mission. Dr. Jim Watzin was recently hired to be the new Mars Program Director, which will bolster cooperation.

Evolvable Mars Campaign

Dr. Jason Crusan presented a briefing on the HEOMD Evolvable Mars Campaign (EMC), currently comprised of architectural analysis for human space flight, and risk reduction activities. The idea for human exploration of Mars is largely derived from the Apollo program, but the current thinking is different. ISS is considered a better thought model for evolving the

capabilities to explore Mars. ISS has multiple purposes; it is a testbed, science platform, and an economic development model for a low Earth orbit (LEO) presence. The pioneering space vision elucidated by President Obama in 2010 supports the extension of human presence further from Earth for increasingly long periods of time. The NASA Strategic Plan Objective #1.1 reflects this vision. The Evolvable Mars Campaign uses a trade analysis that explores ways to further technologies that will lead to human presence at Mars. Its three phases are Earth Reliant, Proving Ground, and Earth Independent, phases that will include iterative evaluations of propulsion systems, habitats, and launch vehicles. Strategic principles for sustainable exploration include implementation within realistic budgets, leveraging robotic expertise, application of high-TRL technologies for near-term missions, execution of near term-missions with a defined cadence for incremental build-up of capability, opportunities for commercial entities, multi-use evolvable space infrastructure, and substantial international and commercial cooperation.

NASA must avoid the stop-and-start policy that marred the Apollo and Shuttle programs, and will need to work with multiple partners in joint interests into the 2030s. The recently published Global Exploration Roadmap elucidates seven common goals and objectives, including the involvement of commercial opportunities to develop routine transportation, such as commercial resupply of ISS. In addition there is a Broad Area Announcement in effect for ARM, a Mars Telecom Request for Information (RFI), and an Evolve ISS RFI.

Strategic Knowledge Gap (SKG) identification is an effort that was initiated by the late Dr. Mike Wargo. SKGs are questions that need to be answered before certain aspects of exploration can be achieved. SKG development is ongoing and is overseen by the Lunar Exploration Analysis Group (LEAG) and the Mars Exploration Program Analysis Group (MEPAG). Notable topics under the SKG heading are radiation, regolith, reliability, which serve to focus various R&A activities. Payloads on the Mars 2020 mission will address SKGs for future human missions. The EMC will define a pioneering strategy and operational capabilities that can extend and sustain human presence in the Solar System, including a human journey to explore the Mars system starting in the mid-2030s. Pointing the way forward, 2014 studies have focused on analyzing transportation, staging and trajectories; deep space surface operations in micro-gravity; a human-class Mars Surface Lander; SLS upper stage capabilities; an extension of ARM's solar electric propulsion (SEP) capabilities; and a Mars habitation campaign.

The Proving Ground objective of EMC will enable Mars missions, and represents the phase of demonstrating SLS and Orion in deep space; conducting deep-space extravehicular activities (EVAs) with sample handling; demonstrating *in-situ* resource utilization (ISRU) in micro-gravity conditions; demonstrating long-duration deep space habitation systems; and moving large masses with SEP. Major results to date indicate that one SLS launch per year, combined with Exploration Upper Stage (EUS) and cargo capability, will greatly increase the value of crewed

missions. Dr. Crusan displayed various options, payload accommodations and fairing sizes associated with EUS.

Risk reduction objectives for future Mars and deep-space missions include development of sensor suites and proximity operations that can be used for both science and human space flight; enhanced interaction with uncooperative low-gravity targets; and long duration, high-power SEP. Split mission concepts are being considered for Mars exploration, representing a variety of approaches, including multiple flights to pre-emplace assets on Mars ahead of human presence. FY15 forward study work includes launch vehicle concept development in coordination with SMD and STMD; habitation refinement, and in-space transportation; Phobos/Deimos human exploration; lunar polar volatiles; SEP; and ISRU integrative test plans. Advancement of Mars capabilities is also being carried out through the Mars Curiosity rover, developments in ISRU (Mars 2020), and entry, descent and landing (EDL) enhancement. An agile and sustainable architecture that is robust across election cycles and economic conditions will be necessary for the success of EMC.

Dr. Condon commented that while HEOMC supports the EMC approach, its nebulous objectives make it difficult to engage the public and Congress. Mr. Bowersox enumerated the major points of EMC, such as an SLS launch once per year, cis-lunar habitation, and bringing the transit habitat back to lunar distant retrograde orbit (DRO). Resource generation at Mars is another significant finding, particularly as recent results indicate there is more water at Mars than previously thought. Dr. Crusan noted that commonality of the systems is also important, as it is important to minimize dead-end investments. Trades among co-manifesting capabilities must also be considered, as well as chemical propulsion vs. SEP vs. a hybrid approach (refueling). Ms. Nancy Ann Budden felt that one must regard EMC in the context of decades of exploration; historically, there have been frustrations in the committees with a lack of a stated mission. However, NASA has successfully used a methodical progressive activity even in the absence of a specific target, which has yielded progress. A technology-based approach is still a viable strategy.

Dr. McComas asked if there was a relationship between EMC and ARM. Dr. Crusan noted that any given mission contributes in some way to overall capabilities. ARM benefits Mars, as it will demonstrate the value of electrical propulsion in large-scale placement of assets, a crewed mission in DRO, and operations in deep space. The value of ARM is the advancement of those capabilities that will enable Mars exploration. Mr. William Gerstenmaier, HEOMD Associate Administrator, commented that the value of DRO had not been immediately obvious until HEO considered ARM; using the Moon as a fueling depot (for water) has opened a trade space of advantages. The solar electric bus for ARM could also be used for Mars cargo movement. Mr. Dick Malow cited Curiosity data on cosmic ray exposure that seems to have indicated that a six-

month trip would not require protection for a human crew. Mr. Bowersox noted that there is new data on radiation exposure, which will be briefed in a future meeting. Dr. McComas commented that it is urgent that the SC get a briefing on radiation, as the issue drives the larger trade studies.

Public Comment Period

Comments from the public were invited. Mr. Keven Miller of Strategic Space Solutions commented that the presentations were terrific and that he found noteworthy Mr. Crusan's statement that at least an annual cadence for SLS is needed. Mr. Miller asserted that it is critical that each of those missions is prioritized. He asked whether there is a process in place for making those evaluations.

Joint Discussion Period

Mr. Bowersox commented that the joint committees do not yet have a firm finding. Dr. Lindberg offered an observation from the Planetary Protection Subcommittee (PPS), which has stated that it is pleased to note a significant increase in the interaction between HEO and the Planetary Protection Officer (PPO) in discussions regarding planetary protection in HEO activities. Members discussed the position of the PPO within the SMD and whether or not the position should not be equivalent to an independent technical authority. Dr. Lindberg noted that there are processes that are established and followed agency-wide. The PPO has many attributes that lend themselves to those processes governing Safety and Mission Assurance (SMA) and good engineering practice, but planetary protection has not yet been adopted as an agency-wide systems engineering concept. He added that the NAC did bring forward the recommendation that the PPO report to the Administrator, but that there were practical concerns keeping the PPO in SMD. Dr. Luhmann noted that PSS has found that the AGs could benefit from joint charters from the joint committees. Mr. Joseph Cuzzupoli requested that a library be established to hold the data that the HEO Committee needs to see to accomplish its work. Dr. Spence suggested the appointment of a liaison that has primary responsibility for making the connections between HEOMD and SMD. Dr. Pieters noted that the AGs answer to both HEOMD and SMD, but only report to SMD. Dr. Luhmann commented that in the past, HEOMD has asked AGs to do studies that address SKGs, which is another reason it would be worthwhile to formalize the relationship.

Dr. Green, noting that with the 2020 Decadal Survey coming up, Flagship missions are currently considered out of the box, thus it may be worthwhile to expand concepts to include human capability in a science mission (such as in the construction of a large telescope). Dr. Peterson added that one can make telescopes of arbitrary size in zero gravity, and that it would be tremendously exciting to have a human-constructed space telescope; this has been a missed opportunity. Mr. Bowersox felt there was a potential to involve the public and university groups in the EMC, and urged casting the net wider. Dr. McComas suggested putting out an Announcement of Opportunity (AO) as that is the standard way to engage university groups. Dr.

Luhmann supported the creation of a firmer vision of how international collaboration plays into future missions. Mr. Bowersox cited Global Exploration Roadmap activities, as well as a call from OSTP in this vein. Dr. Crusan pointed out two major activities, one a 14-nation consortium; and an effort (International Space Exploration Forum (ISEF)) led by the State Department, that are relevant to international collaboration. Dr. Condon suggested that NASA consider both international and industry resources, and asked whether NASA could demonstrate a resource strategy and plan, and communication strategy and plan. Ms. Bartell commented that NASA doesn't sell itself very well; the EMC presentation was good at illustrating the technical details, but needs to be clear why the EMC is important to anybody but NASA. Mr. Malow noted that NASA must be doing something right, in that it received a surplus of $800M over its budget request. Mr. Gerstenmaier felt that HEOMD's public outreach activity for Orion's EFT-1 test flight, laid out months in advance, had been effective, adding that for 2015, the directorate is going to consider every human exploration activity to see whether it warrants special coverage. Once the EMC document comes together, HEOMD will do still more public engagement. Mr. Gregory Williams noted that at the agency and directorate levels, there are distinct communication strategies. For EMC in particular, NASA has started to reach out to the technical community, and has started to see some impact. Responding to concerns about the focus of the program, Mr. Gerstenmaier noted that the directorate tried to couch EFT-1 in the context of pushing out into the Solar System, focusing on acquiring broader knowledge rather than a single objective. Reactions from a recent social media event were positive towards this approach. Dr. Luhmann asked whether the objective of EMC is to search for life at Mars, or to colonize Mars; these types of answers are needed. Mr. Gerstenmaier described the objective as pushing human presence in the Solar System in a sustainable way; it would take the least amount of work to put a human on Mars as compared to other planetary destinations. The Moon could provide a gravitational assist, and maybe ISRU on the journey to Mars. There is also genetic evidence that dispersal into more hostile areas of Earth was critical in evolving the human species.

No findings or recommendations were recorded.

January 13, 2015

Ms. Denning announced a change in the agenda to accommodate Dr. Grunsfeld's travel schedule. Ms. Kristen Erickson's briefing on NASA's Education was moved to 9:30.

Discussion with SMD Associate Administrator

Dr. Grunsfeld noted that there was an enormous amount of informal collaboration with Aeronautics and HEO in the transition from pure operations with Space Shuttle and the International Space Station (ISS) to the Journey to Mars. In the path, there will be more

discussion of science measurements, which will have direct relevance to human exploration; it is all very coupled. Dr. McComas brought up the travel topic as a potential finding, expressing appreciation of Mr. Woods' earlier briefing on the interpretation of travel restrictions, but also expressing concern with NASA's decision to include contractors with civil servants. Dr. Grunsfeld emphasized that bringing scientists together is a fundamental part of how scientists work. He surmised that the contractor issue might have arisen because it was decided that JPL contractors were not excluded from the guidance even though they are a part of CALTECH. Dr. Grunsfeld welcomed ideas from the SC. Dr. Lindberg suggested that NASA might explore with OMB how the Department of Energy (DOE) has handled the same issue with its contractors. Dr. Mark Robinson addressed Mars strategies such as the development of autonomous landing capabilities beyond those of Curiosity and the Mars Exploration Rovers (MERs), resource prospecting in the Solar System, and resource utilization; he commented that a series of focused missions with milestones would help bring human exploration goals into focus, as well as getting the public and Congress interested and engaged. Dr. Grunsfeld agreed, adding that the combination of competed and directed missions can be used to plan for post-2020 Mars while maintaining the program balance. Much depends on what Curiosity finds at Mt. Sharp; and once a 2020 caching system is developed, the program will need a viable plan to bring samples back to Earth. The MEP will need to demonstrate a round trip to Mars before humans can be sent. The budget for human space flight will influence this planning process as well. SMD is working on this, engaging the MEPAG and other AGs to help guide the process, as well as the upcoming 2020 Planetary Decadal Survey.

Dr. Luhmann asked if SMD were flexible enough to adjust to changing directives along the way, and in particular whether there was still human/lunar activity underlying the planning. Dr. Grunsfeld responded that while NASA clearly has the challenge of cyclic politics, there is a lot of bipartisan support for NASA in Congress. SLS and Orion have heritage in lunar exploration, and were designed for a lunar orbit mission. Architecturally, there is much flexibility down the road, also with commercial crew and cargo. The other issue is the 11-year time scale of solar activity. Asked about a de-orbit of the Hubble Space Telescope (HST), Dr. Grunsfeld reported that 2027 is when the telescope might become uncontrollable (if the solar cycle remains quiet, HST could make it to 2030). Funding will start to appear to develop a small robotic system to dock underneath HST with a motor, either to send it further out, or de-orbit it into the Pacific. Fine guidance sensors probably will be the limiting factor, but NASA hopes to get another 5 years out of it. Dr. Hagan asked for a brief update on HPD, in particular with respect to the search for a new director. The Magnetospheric Multiscale (MMS) mission is proceeding to a March launch, and the science community wants to coordinate MMS with THEMIS and the Van Allen probes with MMS. Dr. Grunsfeld reported that progress is being made in the Solar Probe Plus mission, as well as in increasing the Diversify, Realize, Integrate, Venture, Educate (DRIVE) initiative. All applications are in house for a new HPD director, and a selection team is

in place. An announcement is expected in March.

Education and Communications Update

Ms. Kristen Erickson, Director, Science Engagement and Partnerships (SE&P), expressed appreciation for the Science Committee's attention to the science program, and gave a status on the restructuring of NASA's former Education and Public Outreach (EPO) program. She displayed a requested organizational chart, in which she was shown as a direct report to Dr. Marc Allen. Dr. Allen is the Deputy Associate Administrator for Research. The Education and Communications Specialist position is still vacant but efforts are underway to fill it. NASA's definitions for education and communications, established in 2011, serve to guide the current restructuring efforts. Communications comprise media services, multimedia products and services, and public engagement (outreach). Restructuring efforts are rooted in enabling NASA scientists and engineers to engage with all learners more efficiently and effectively. At any one time, there are about 100 missions in formulation, development or operation. Formerly, these separate mission teams set aside 1% of their budgets for education and communications and were overseen by the four science disciplines. Education and communications (E&C) is now going forward on a discipline basis and not by mission, in the hope of having a more distributed, decentralized approach to engaging with learners.

Public school education is about a $600B annual endeavor, per the National Center for Education Statistics; and NASA was appropriated $42M for education this year. There are currently four guiding objectives under this aegis: enable Science, Technology, Engineering and Mathematics (STEM) education, improve U.S. scientific literacy, advance national education goals, and achieve leveraging through partnerships. The objectives are a reflection of the Decadal Surveys. Leveraging through partnerships, for example, can improve local school communities by having NASA participate with community-based groups that are already engaged with the schools.

The SMD Science Education Model presumes that SMD assets are used by Science Education Providers to translate data to useful information for end users, to develop curricula and other education materials, and to enable subject matter experts to share NASA science with target audiences. A Cooperative Agreement Notice (CAN) draft text was released in November 2014, and the final CAN will be released later in January. NOIs are due in February, and full proposals are due in April. All information on the CAN can be found on NSPIRES. Awards will be announced by the summer and distributed before the end of the fiscal year. After the release of the final CAN this month, there will be a virtual pre-proposal conference, with each Division Director providing their perspectives. In FY15, NASA has extended the current four division discipline forums to assist in the restructuring; the GLOBE program in ESD remains unchanged. The rest of the monies for FY15 will go toward the new awards. SE&P also interacts with the NASA Office of Education, and is a member of the Education Coordination Committee.

SMD is also embarking on a science communications restructuring process. Communication is integral to science and engineering: science isn't done until it's shared. To this end, the SE&P has created an internal working group made up of Communication Leads in each division, which meets on a biweekly basis. Unlike Education, Communication still will be managed through mission and non-mission activities. The office now employs a fellow, Dr. Michelle Thaller, a professional science communicator, and has asked her to develop a 60-day assessment of science communication products. SMD will be taking her recommendations and working on a plan on how to go forward with science communications. The three fundamental questions being used to guide Science Communication are: what is NASA science? how does NASA do science? and why should people care? The general public is the target audience. Next steps include working to help update the relevant Science Policy Document (SPD).

Dr. McComas commented that the Science Committee has been especially concerned with science education and is delighted to see a replenished budget, but he expressed two personal concerns. The first concern is that NASA continue to embrace the smaller missions and grants in E&C. The second concern is that NASA PIs continue their pro bono efforts from get the message out and convey their valuable enthusiasm. Dr. Running, referring to Earth Science videos, commented that Goddard's visualization services, animations of data sets, etc., are very valuable. Ms. Erickson noted that there are certain infrastructure activities available across SMD that will be listed in the final text of the CAN. Dr. Thaller has recommended the expansion of Agency-wide assets to support E&C. Ms. Erickson commented that the intent is not to set up a cutthroat environment, but rather to incentivize partnering and sustainability. Dr. Robinson reiterated the importance of public talks given by PIs, and NASA press conferences conveying exciting results. Ms. Erickson noted that NASA encourages and authorizes its employees to do this; it doesn't require a separate charge code. With regard to the CAN, SE&P is looking for innovative ways to improve the process, with simple things such as travel gift cards or actual stipends. With regard to agency communications, Ms. Erickson felt the connectedness could be improved. There are 6 campaigns, such as Earth Right Now, in which Communications has been involved. Dr. Robinson's LRO work in lunar surface mapping was held up as one example. Dr. Thaller asked if the community was worried that NASA would lose staff to help PIs get the word out. Dr. McComas pointed out that PIs once had EPO help in getting the word out on small missions; mission focus helped leverage a certain amount of outreach, which enabled the PIs to put out a quality effort. Ms. Erickson stated that the intention is to retain the mission communication function. Dr. Robinson commented that lack of funding for educational materials has been discouraging. Lack of these materials tends to discourage team members; they are important for engaging young students. Ms. Erickson agreed that the loss of funding had been devastating, and that the intention is to regain these tools. Dr. McComas pointed out that people lost their jobs as a result of these cuts; the long-term implications are not over yet. It is really critical to foster

people who have done good work in the past.

Subcommittee reports

Dr. McComas noted that because of the short SC meeting and joint session with HEO, there was unfortunately no time to include Division Director briefings. He asked that the subcommittee reports cover critical Division updates, but also retain adequate time to present their findings and recommendation for consideration by the full SC.

Planetary Science Subcommittee

Dr. Luhmann, Chair of the Planetary Science Subcommittee (PSS), reported good budgetary news for PSD. At $1.438B, the budget is better than it has been in the recent past. There is funding for Discovery and New Frontiers future investment, $255.8M for research, and funding for a Europa mission. PSD has a full plate in 2015: Dawn will approach Ceres; New Horizons will arrive at Pluto; the Europa instrument call will have its Step 1 selection; the MESSENGER spacecraft will impact Mercury in early April, and talks with ISRO will be held on future missions at Mars. At PSS's most recent meeting, the subcommittee heard a Lessons Learned (LL) briefing on the LRO mission, which highlighted the successful collaboration between Exploration and SMD. As expected, findings of the LL team recognized the need for buy-in at the AA level, strong advocates for science on both sides, and the need for an SMD counterpart to represent science on the Exploration side, so as to keep lines of communication open and to ensure that science is represented in a meaningful way.

PSS findings:

The outcome of the Planetary R&A re-organization is still being evaluated, and the division is monitoring user satisfaction. Restoration of the PI-led mission cadence is being enabled by budget, but PSS would still like to see a target date on a New Frontiers call. There is an uncertain future for large SMD missions, and there are concerns about how to do the Europa mission in the budget environment. Excellent SMD/HEOMD cooperation regarding the Lunar Reconaissance Orbiter was reported. There was one comment that there should be one science representative in the partnership that reports to both AAs of SMD and HEOMD, and Dr. McComas recommended that the Subcommittee discuss this. Dr. Luhmann recommended two findings to take forward to the NAC; PSS finds there is a need for Agency-level consideration of a dedicated NEO survey mission, as there is still much work to be done to fulfill the George Brown Act. Secondly, PSS finds that NASA should take more advantage of opportunities for international collaboration on missions. ESA recently had a call for M-class missions; if NASA and ESA merged efforts, they could create an ice giant mission, the equivalent of a small Flagship.

Recent and notable highlights in international planetary science missions include the discovery of lunar frost by an instrument on the ISRO mission, Chandrayaan; the highly successful Rosetta

collaboration; cooperation on Mars Express; and the inclusion of European instruments on NASA's InSight seismic mission at Mars. A South Korean lunar mission is scheduled in 2017. Science nuggets include MAVEN results that indicated the presence of ionized magnesium in the Mars atmosphere subsequent to the passing of the Siding Spring comet. Rosetta carried out a spectacular event with the lander Philae. Dawn sent back some first images of Ceres in advance of its orbit insertion, and New Horizons is ready for Pluto. HST has also imaged some Kuiper Belt objects for the New Horizons spacecraft to investigate. LRO has shown that the Moon was volcanically active as late as the Cretaceous period on Earth. The Curation and Analysis Planning Team for Extraterrestrial Materials (CAPTEM) has reported evidence of solar wind having produced water on interstellar dust particles. Cassini has provided further imaging of jets on Enceladus. Cassini was shocked by Hyperion's 200 V electron beam.

Astrophysics Subcommittee

Dr. Peterson, Chair of the Astrophysics Subcommittee, reported that the SMD Astrophysics Division (APD) has recently issued an update to its Implementation Plan describing evolution of the Plan in the past two years (since the original Implementation Plan was published in 2012). He reported science results including imaging that indicates that exoplanets are likely to be found around stars embedded in circumstellar dust and that the black hole in the center of the Milky Way may be a factory for very high-energy neutrinos. Current astrophysics missions include one in its primary operation phase (Stratospheric Observatory for Infrared Astronomy; SOFIA), while others are in formulation, implementation, or extended operation phases. Total funding for APD is $1.3B in FY15, which fully funds a James Webb Space Telescope (JWST) launch in 2018. SOFIA's budget has been partly restored, at a 17% reduction from FY14. The Wide-Field Infrared Survey Telescope (WFIRST) mission is in pre-formulation, and progress is being made against the recommendations of the 2010 Astrophysics Decadal Survey. JWST is proceeding well, on budget and on schedule; 2015 is the year of assembly. There are no major issues to bring forward for JWST; there is still funded contingency in the budget and schedule. NASA will mark the 25th anniversary of the launch of the Hubble Space Telescope (HST) with events, including re-release of the "Hubble 3D" movie in IMAX format. APD is still studying a pre-formulation plan for WFIRST, addressing some loss in the desired infrared range and the possibility of including a coronagraph.

NASA and NSF have partnered on a joint program of exoplanet research using the National Optical Astronomy Observatory (NOAO) share of the WIYN (Wisconsin-Indiana-Yale-NOAO) telescope on Kitt Peak. Astrophysics ROSES funding has grown by 10% over the last decade, while proposal numbers have more than doubled at the same time. As a result, selection rates have dropped to less than 20%, representing a huge problem for the astrophysics community. Planning has begun for the mid-decade review and for the 2020 Decadal Survey; APD has produced a list of mission concepts for the latter and the Program Analysis Groups (PAGs) have

been asked to comment on the list: a Far-Infrared Surveyor, a Habitable Exoplanet Imaging Mission, an UV-Optical-IR Surveyor, and an X-Ray Surveyor. All current astrophysics operating missions are in extended mission phase, with the exception of SOFIA (Stratospheric Observatory for Infrared Astronomy). Dr. Green commented that he was trying to understand the available funding wedge for WFIRST: How does it get executed if the cost is now $2B? What has changed? Dr. Hertz responded that WFIRST can't be developed until JWST approaches launch. The year 2024 is a possible launch date for WFIRST, notionally, if development begins in FY17 and if adequate funding is available. Asked how WFIRST remained scientifically relevant, Dr. Hertz noted that the NRC issued a report stating that the current design reference mission for WFIRST exceeds the science value for WFIRST called out in the Decadal Survey. APD is spending funds appropriated for WFIRST in FY15 to reduce the risk of the imaging detector and coronagraph technologies; they are currently on schedule to be at the appropriate TRL when needed. WFIRST would go without the coronagraph if it proves to have problems - it is de-scopable. The cost of WFIRST with and without a coronagraph will be determined by a Cost and Technical Estimate (CATE) in February. In response to a question, Dr. Hertz noted that the flight rate will be affected for SOFIA operations due to a 17% budget reduction, but APD still anticipates to be able to deliver Guest Observer science and further development of second-generation instruments.

Dr. Peterson had no findings or recommendations to bring forward.

Discussion of Findings and Recommendations

Dr. McComas felt the Committee should hold any findings on E&C, and re-assess the issue by July. Dr. Robinson suggested that it might be useful for NASA to give explicit direction to missions that had lost education monies, settling the issue of how to handle previous losses. Dr. Hagan requested an inventory of what was lost and how to develop guidance for existing missions that formerly had EPO funds. Dr. McComas requested that information be provided on what part of the inventory is being funded. These actions were recorded by Ms. Denning as follow-up items.

The Committee considered the PSS findings on NEOs and international collaboration. On NEOs, the Committee considered the science value of a finding for a dedicated NEO survey. Dr. McComas said he was uncomfortable having a formal SC finding on how well NASA is responding to a non-science Congressional mandate, given that the Science Committee's expertise and place was to deliberate and comment on science issues, but that he was still willing to bring it to the NAC for discussion. A formal finding on this matter was deferred.

A finding on technology infusion finding was deferred. Dr. Green recommended the Committee hear a briefing from someone with TMCO experience to explain how risk assessments are done

for new technologies. Ms. Denning took an action to arrange the briefing.

IBEX Presentation

Dr. McComas gave a lunch presentation on the science results from the IBEX (Interstellar Boundary Explorer) mission.

Subcommittee Reports

Earth Science Subcommittee

Dr. Running provided a report on the most recent outcomes of the Earth Science Subcommittee (ESS). There are no current findings or recommendations for the Science Committee to consider. The FY15 budget for ESD is nearly $1.9B; ESS appreciates the stability of the budget environment. One callout from FY15 Congressional appropriation language regards the Sustainable Land Imaging mission (formerly Landsat) to continue the Landsat data stream without necessarily adhering to the traditional imaging model. ESD has been allocated $64M to continue the coverage.

Satellite launches of the last year included Global Precipitation Measurement (GPM), Orbiting Carbon Observatory (OCO-2), RapidScat and the Cloud Aerosol Transport System (CATS) launched very recently. The Soil Moisture Active Passive (SMAP) mission is due to launch this month and may prove to be the best global warming monitor ever seen, given its enhanced ability to measure freeze-thaw cycles. The ESD 2015 Senior Review has evaluated a number of missions, including Terra/Aqua, which is now projected to remain stable until 2022. Other missions under review are the Gravity Recovery And Climate Experiment (GRACE), CloudSat and-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO), CloudSat and Aura. Early OCO-2 data on atmospheric CO_2 measurements are close to Goddard Space Flight Center (GSFC) model predictions. Early investments in technology development have enabled a Hurricane and Severe Storm Sentinel Venture-class airborne mission, carried on an unmanned aerial vehicle (UAV). ISS has been especially useful for prototyping new Earth science instruments, such as the Stratospheric Aerosol and Gas Experiment III (SAGE III) (2016), the ISS SERVIR Environmental Research and Visualization System (ISERV) (2012-15), and RapidScat (2014). Two new missions have been selected for 2020 deployment; these will monitor carbon and water balance in terrestrial systems. Venture-class missions, which are relatively inexpensive, science-driven, PI-led, competitively selected missions, are also helping to advance innovation. The Venture-class program is comprised of three strands: suborbital, small-sat and instruments. Planning is under way for the next Decadal Survey.

Science results from the Moderate Resolution Imaging Spectroradiometer (MODIS) have identified carbon sinks in cropland, helping to improve global crop forecasting. MODIS has also

provided new data on sun-induced chlorophyll fluorescence from terrestrial plants, which is emerging as a significant new topic. MODIS has been able to provide quantifiable data on seasonal timing; spring is coming earlier and autumn later. GRACE mission results on groundwater depletion in the Colorado Basin now indicate a permanent and grave loss of groundwater. GRACE also is helping to predict areas of vulnerability to flooding several months ahead of time. Flooding costs the United States more money than any other natural disaster. Satellite altimetry data is now serving to correct sea-surface height measurements. Data from ICESat (Ice, Cloud, and land Elevation Satellite), Operation IceBridge, and GRACE have provided further evidence of Antarctic ice sheet melting.

Heliophysics Subcommittee

Dr. Hagan presented results from the Heliophysics Subcommittee (HPS). Upcoming missions in the HPD are the Magnetospheric Multiscale (MMS) mission, Solar Probe Plus (SPP), Space Experimental Testbed (SET) and the Solar Orbiter Collaboration (SOC). Newly announced Explorer selections are the Ionospheric Connection Explorer (ICON) and Global-scale Observations of the Limb and Disk (GOLD). ICON reached its Key Decision Point (KDP)-C milestone in October; GOLD is due for KDP-C in February 2015. The Critical Design Review (CDR) for SPP is March 2015. The SOC launch is scheduled for October 2018, with a launch readiness date (LRD) of July 2017. The 2015 ROSES call will be released in February, and there will not be another heliophysics Explorer solicitation until 2017—the cadence of this program remains a concern to HPS. Dr. Jeffrey Newmark, Acting Director of HPD, noted that the last Explorer was held in 2002, with a final selection in 2005. The last Living With a Star (LWS) mission was the Van Allen probe. A Senior Review for Heliophysics missions will be held in April of this year.

HPD is managing the new CubeSat initiative ($5M per year). Proposals for CubeSats are made through ROSES and are selected by each SMD division. Proposals will be solicited and selected on the basis of science merit and technology value. Five heliophysics and one Earth science selection were made in 2014. The average award is 3 years, representing about $2-3M per CubeSat. The hope is to launch 2-3 SMD-sponsored CubeSats per year once it is up and running.

The Heliophysics Roadmap is still in the process of being finalized. The Roadmap team and HPS anxiously await its publication, having concluded their work on the document in early 2014 when they handed it over to HPD for copyediting. The Roadmap implements the recommendations in the Decadal Survey. HPD has been significantly constrained by the budget, which translates to a greatly protracted timeline.

HPS has been in the process of reconstituting itself as a committee; six members rotated off in July. HPS now has a full membership, and the new Executive Secretary is Dr. Ramona Kessel.

Since July, HPS has had one meeting with the full membership on board to carry out the annual performance review (Performance and Accountability Report: PAR) for heliophysics science, which resulted in three unanimous green votes. HPS also heard briefings on low-cost access to space (LCAS) strategic and budget priorities, Education and Communication, and interagency cooperation and collaboration.

The subcommittee also held a teleconference on 11 January to react to a proposal to combine the Strategic Research and GI programs for the 2015 ROSES call. HPS has recommended against this move because it would remove focus on active missions, while not representing any significant savings. HPS did agree to recommend tightening up criteria for each of the programs in order to address Headquarters issues. HPS agreed to include this recommendation in a letter to the SC Chair that would be cc:d to the HPD Director.

Recent science highlights include an observation by the Solar Dynamics Observer (SDO), which imaged a giant coronal hole on New Year's Day. High-speed plasma streams associated with coronal holes can interact with Earth's radiation belts and cause space weather events that have potential societal impact. On 12 January, SDO observed an M-class flare. Interface Region Imaging Spectrograph (IRIS) measurements have shown novel mini-tornadoes in active regions on the Sun, which may provide a mechanism for transferring energy. The Van Allen Probes detected an "impenetrable barrier" in local space, a sharp boundary that blocks the passage of some of the fastest, highest-energy electrons. Voyager 1 has measured another "tsunami wave" associated with a coronal mass ejection (CME), and the Wind mission celebrates a 20th anniversary this year.

Planetary Protection Subcommittee

Dr. Lindberg reported on the Planetary Protection Subcommittee (PPS) in place of PPS Chair Dr. Eugene Levy, first giving a background on planetary protection requirements for preventing forward and backward contamination, as more information emerges on the range of conditions in which extremophiles can survive on Earth. Recent PPS recommendations include improving communications with the Mars Science Laboratory (MSL) Curiosity team during the course of the mission in order to ensure avoidance of "special regions," a region in which a terrestrial microbe could reproduce given specific conditions. The basis for this recommendation lies in the 2011 planetary protection categorization letter for MSL, which forbids contact with potential special regions and requires that the mission science team immediately report such potential contact. Over the course of the MSL mission, indirect evidence of subsurface water, which is a criterion for special region designation, has been mounting, but has not been reported to the Planetary Protection Officer (PPO). Other evidence includes the possible existence of recurring slope lineae (RSLs) within the projected traverse area of the Curiosity rover, and the detection of methane spikes within its vicinity. Dr. McComas felt that the PPO could simply attend MSL

Working Group meetings to keep abreast of mission activities. Dr. Lindberg reported that the obligation is on the science team to report to the PPO. Dr. Catharine Conley, PPO, reported that she has had conversations with Dr. Watzin, the new Mars Exploration Program (MEP) Director to rectify the issue. Drs. McComas and Lindberg felt the matter could be handled by a letter.

A second PPS recommendation regarded non-governmental space actors; PPS recommends that NASA's internal review of licenses for commercial launches and re-entries include an assessment by SMD/PPO to determine whether the licensees comply with NASA planetary protection policy requirements. It was also noted that the recommendation deals with planetary protection concerns that are outside the direct influence of the PPS. Dr. Lindberg stated that the recommendation is partly driven by intention of the private entity, MarsOne, to place a lander on Mars containing a plant-growth experiment. Dr. McComas suggested that NASA might need to reach out to the Federal Aviation Administration (FAA) and open a dialogue, but that any action would need to be taken at the NAC level. Dr. Lindberg agreed to provide a concise slide to Dr. McComas to brief to the NAC.

PPS observations include an expression of appreciation that the Mars 2020 mission has been structured to better facilitate the flowdown of planetary protection requirements early in the design phase, in response to an MSL Lessons Learned study. The InSight mission also has responded favorably to the study recommendations. In addition, PPS was pleased to note the increased interaction between HEOMD and the PPO, and the generation of a new NASA Policy Instruction (NPI) regarding planetary protection in human exploration. PPS also appreciates SMD's response to its recommendation on modifying the reporting line of the PPO.

PPS has closed out a letter of agreement (LOA) with the European Space Agency's (ESA) parallel organization, however PPS holds as an open action the intent to continue joint meetings with ESA; recent developments in planetary protection highlight the need for a joint meeting in 2015. PPS is currently in the process of reconstituting itself with continuing representation from ESA, the Canadian Space Agency (CSA), France's Centre National d'Etudes Spatiales (CNES), and the Department of State.

Ad Hoc Big Data Task Force

Dr. Erin Smith, Executive Secretary of the Ad Hoc Big Data Task Force, reported on its status. The task force was created in order to leverage data sets such that non-NASA users can more easily take advantage of them. NASA has been charged with making NASA Earth observations usable across government agencies, as well as for the public. The goal of the task force is to enable interoperable data sets that can facilitate new science, better use of data for decision support, and potentially actionable science information. Large data sets demand an understanding of architecture and tools for current and future needs. The task force will explore

existing infrastructure, data sharing, and universality of tools. It then will catalogue best practices and investigate federal initiatives related to big data and data access. As appropriate, the task force will brief the Science Committee. Membership is in the process of selection; good representation is expected from all the SMD sub-disciplines. All nominees have backgrounds in large data. There will be 10 seats, and the proposal is for 8 representatives from the 4 scientific disciplines (heliophysics, Earth science, astrophysics and planetary science), 1 aerospace representative, and a Task Force Chair. Dr. Robinson expressed concern that the membership was largely from the NASA domain. Dr. Lindberg agreed, adding that the state of the art is represented much more effectively by the public domain in companies such as Google, Microsoft, etc. He urged that the Task Force hear from commercial entities as well. Dr, Robinson suggested that representation of other industries/scientific fields (e.g. seismology) would be better than the current proposal. Dr. Green noted that other areas have more data (e.g. ground-based science, Large Synoptic Survey Telescope (LSST)) and that it was important to have a focus on interoperability such as that seen in the National Virtual Observatory portal.

Dr. Smith reported that 70 candidates are being considered for the task force, with the nominee list nearly finalized and under review. The appointment process will follow the Federal Advisory Committee Act (FACA) process. A complete nominee review will be completed by the end of January, and the goal is to have the first task force meeting prior to the next Science Committee meeting. Asked what the end-product of the task force will be, Dr. Smith responded that the value is seen in having a group that can be points of contact for big data issues.

In discussion of what the task force should do, Dr. Green commented that the real issue is data usage, not just access. Dr. Spence said the role should be to provide and manage the data, and support analytics; and posed the question of whether the task force was to be transformative or incremental. Dr. Lindberg asked how new techniques for data visualization in private industry can be adapted to NASA science. Dr. Robinson underscored that NASA is concerned with the permanence of data, as well.

Dr. McComas noted that there was discomfort from the committee on these matters. The committee agreed to assess the Task Force's progress in April 2015.

Discussion/Findings and Recommendations

The committee reopened a brief discussion on NEOs. Dr. McComas requested that Dr. Luhmann provide evidence that there is support in the Decadal Survey for a dedicated NEO effort before the Science Committee goes forward with a recommendation.

The committee refined the wording of the travel restriction finding using prior recommendations developed by APS.

A finding on two-step R&A proposals was deferred until more data was accumulated on number of proposals reviewed and how these fared.

Ms. Denning and Dr. McComas took actions to work on the April meeting agenda. Dr. Hagan urged that there be radiation briefing at the next joint meeting between HEOMD and SMD. Dr. McComas adjourned the meeting at 4:35pm.

Appendix A
Attendees

NAC Science Committee members
David McComas, Southwest Research Institute, ***Chair, Science Committee***
Douglas Duncan, University of Colorado at Boulder
James Green, University of Colorado
Maura Hagan, NCAR, Chair, Heliophysics Subcommittee
Robert Lindberg, University of Virginia, Vice Chair, Planetary Protection Subcommittee
Janet Luhmann, UC Berkeley, Chair, Planetary Science Subcommittee
Bradley Peterson, Ohio State University, Chair, Astrophysics Subcommittee
Carlé Pieters, Brown University *(via telecon)*
Mark Robinson, Arizona State University
Steven Running, University of Montana, Chair, Earth Science Subcommittee,
Harlan Spence, University of New Hampshire
Elaine Denning, NASA Headquarters, ***Executive Secretary, Science Committee***

NAC Human Exploration and Operations Committee members
Kenneth Bowersox, U.S. Navy *(Ret.)*, ***Chair, Human Exploration and Operations Committee***
Shannon Bartell, Aerospace Consultant
Nancy Ann Budden, DoD
Stephen "Pat" Condon, Aerospace Consultant
Joseph Cuzzapoli, Aerospace Consultant
David Longnecker, AAMC *(via telecon)*
Michael Lopez-Alegria, Commercial Spaceflight Federation
Richard Malow, AURA *(via telecon)*
James Odom, Aerospace Consultant
Bette Siegel, NASA Headquarters, ***Executive Secretary, Human Exploration and Operations Committee***

NASA Attendees
Barbara Adde, NASA HEOMD
Louis Barbier, NASA Headquarters
Marguerite Broadwell, NASA
Catherine Conley, NASA Headquarters
Douglas Craig, NASA Headquarters
Jason Crusan, NASA Headquarters
John Duipi, NASA
T. Jens Feeley, NASA Headquarters
Carol Galick, NASA
Dennis Gallagher, NASA
Michael Gazarik, NASA
John M. Grunsfeld, NASA Headquarters
William Gerstenmaier, NASA Headquarters
Lika Guhathakurta, NASA Headquarters
Nicole Herrmann, NASA Headquarters
Tommy Holloway, NASA Headquarters
Marthenia Holmes, NASA Headquarters
Richard Irving, NASA Legislative Affairs

Gordon Johnston, NASA Headquarters
Meredith McKay, NASA
Altonell Mumford, NASA Headquarters
Jeffrey Newmark, NASA Headquarters
Stefanie Payne, NASA Headquarters
Betsy Pugel, NASA Headquarters
Shawanda Robinson, NASA Headquarters
Jennifer Rumberg, NASA Headquarters
Stephanie Schierholz, NASA Headquarters
Erin Smith, NASA Headquarters (ARC detailee)
Al Sompe, NASA Headquarters
Ellen Stofan, NASA Headquarters
Michelle Thaller, NASA Headquarters
Craig Tupper, NASA Headquarters
Brenda Ward, NASA JSC
Gregory Williams, NASA Headquarters
Dan Woods, NASA Headquarters

Non-NASA Attendees
Joe Cassady, Aerojet Rocketdyne
Stephen Clark, Space Flight Now
Anne Connor, Exelis
Dominic Conte, Millennium Space Systems
James Dean, Florida Today
Ashley Edwards, Aspirations Systems Development
Kathryn Flanagan, STSCI
Chris Gilbert, Independent Consultant
David Hermreck, NOAA
Grace Hu, Office Of Management & Budget
Hussein Jirdeh, Space Telescope Science Institute
Jason Kalirai, Space Telescope Science Institute
Dan Leone, Spacenews
James Lochner, USRA
David Longnecker, AAMC, HEO Committee
Richard Malow, AURA
Kevin Miller, Strategic Space Solutions
David Millman, Unaffiliated
Amanya Moro, Space Telescope Science Institute
Richard Passmore, European Space Agency
Joel Parriott, American Astronomical Society
Duane Ratliff, Contineo
Neill Reed, Space Institute
Allison Rose-Sonnesyn, House Science Committee
Shelby Russell
Josh Shiode, American Astronomical Society
Denise Smith, Space Telescope Science Institute
Marcia Smith, Spacepolicyonline.com
Ryan Stethan

Billy Stewart, CSC - Audio/Visual Tech
Jared Stout, House Science Committee
Paula Wamsley, Ball Aerospace
Robert Zimmerman, Symbiotec
Ana Wilson, Zantech IT
Joan Zimmermann, Zantech IT
Ann Zulkosky, Lockheed Martin

Appendix B
NAC Science Committee Membership

Dr. David McComas
Southwest Research Institute (Chair)

Dr. Douglas Duncan
University of Colorado at Boulder

Dr. James Green
University of Colorado

Dr. Maura Hagan
National Center for Atmospheric Research

Dr. Eugene H. Levy
Rice University

Dr. Janet Luhmann
University of California, Berkeley

Dr. Bradley Peterson
Ohio State University

Dr. Carlé Pieters
Brown University

Dr. Mark Robinson
Arizona State University

Dr. Steven W. Running
University of Montana

Dr. Harlan Spence
University of New Hampshire

Dr. David Spergel
Princeton University *(ex officio Member)*

Ms. Elaine Denning, Executive Secretary
NASA Headquarters

Appendix C
Presentations

1. Instructional and Domestic Travel and Collaboration; *Dan Woods*
2. SMD/STMD Technology Infusion Cooperation; *Michael Seablom, William Lightsey*
3. Research and Analysis Two-Step Process; *Max Bernstein*
4. Overview Presentation of HEOMD/SMD Joint Activities; *John Grunsfeld*
5. Evolvable Mars Campaign; *Jason Crusan*
6. Education and Communications Update; *Kristen Erickson*
7. Planetary Science Subcommittee Update; *Janet Luhmann*
8. Astrophysics Subcommittee Update; *Bradley Peterson*
9. The Interstellar Boundary Explorer (IBEX): The little mission that could; *David McComas*
10. Earth Science Subcommittee Update; *Steve Running*
11. Heliophysics Subcommittee Update; *Maura Hagan*
12. Planetary Protection Subcommittee Update; *Robert Lindberg*
13. Ad Hoc Big Data Task Force; *Erin Smith*

Appendix D
Agenda

NASA Advisory Council

Science Committee

Meeting

January 12-13, 2015

NASA Stennis Space Center
Roy S. Estess Building
Stennis Space Center, MS 39529-6000

Final Agenda

(Central Standard Time)

Science Committee Meeting
Santa Rosa Conference Room, #11111

Monday, January 12

8:00-8:15	Administrative Remarks and Member Introductions – E. Denning / D. McComas
8:15-9:00	International and Domestic Travel and Collaboration – W. Lightsey / D. Woods / P. Hertz
9:00-10:00	SMD / STMD Technology Infusion Cooperation – M. Seablom / J. Sheehy / Discussion
10:00-10:10	Break
10:10-10:55	Research & Analysis Two-Step Process – M. Bernstein / Discussion
10:55-11:05	Public Comment
11:05-12:00	Discussion/Findings and Recommendations
12:00-1:00	Lunch – Stennis Space Center Presentation

Science Committee / Human Exploration and Operations Committee Joint Meeting
Logtown Conference Room, #11161

1:00-1:02	Call to Order & Welcome	Dr. Bette Siegel Ms. Elaine Denning
1:02-1:25	Opening Remarks & Member Introductions	Mr. Kenneth Bowersox Dr. David McComas

1:25-1:30	Welcome to NASA Stennis Space Center	Dr. Richard Gilbrech
1:30-2:30	Overview Presentation of HEOMD/SMD Joint Activities	Dr. John M. Grunsfeld Mr. Craig Tupper
2:30-3:40	Evolvable Mars Campaign	Mr. Jason Crusan
3:40-3:50	Break	
3:50-3:55	Public Comments	
3:55-5:20	Joint HEOC/SC Discussion and Findings/Recommendations	
5:20-5:30	Next Steps and Closing Remarks	Mr. Bowersox Dr. McComas
5:30	Adjourn Joint Meeting	
6:30	Joint Dinner	

Science Committee Meeting
Santa Rosa Conference Room, #11111

Tuesday, January 13

8:30	Call to Order
8:35-9:00	Discussion with Associate Administrator Grunsfeld
9:00-10:00	Education and Communications Update – K. Erickson / Discussion
10:00-10:15	Break
10:15-11:05	Subcommittee Reports / Discussion
	10:15 Planetary Science Subcommittee – J. Luhmann
	10:40 Astrophysics Subcommittee – B. Peterson
11:05-12:00	Discussion/Findings and Recommendations
12:00-1:15	Lunch – Research Presentation: "The Interstellar Boundary Explorer (IBEX): The little mission that could" – D. McComas

1:15	Subcommittee Reports / Discussions
	1:15 Earth Science Subcommittee – S. Running
	1:40 Heliophysics Subcommittee – M. Hagan
	2:05 Planetary Protection Subcommittee – R. Lindberg
2:30-3:15	Ad Hoc Big Data Task Force – E. Smith / Discussion
3:15-3:30	**Break**
3:30-5:15	Discussion / Findings and Recommendations
5:15	**Adjourn**