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MEETING REPORT



David J. McComas, Chair



Deirdre L. Jurand, Executive Secretary

Table of Contents

Welcome and Introduction	3
SMD Science Plan Status	3
SMD Budget Status	4
Earth Science Division Update	5
Planetary Protection Office	7
Discussion	8
Astrophysics Division Update	9
James Webb Space Telescope Status	11
Planetary Science Division	13
MSL Lessons Learned Study	16
NASA Administrator Drop-in	18
ASRG Case Study	18
Discussion with SMD	19
Heliophysics Division Update	20
Public Comment Period	22
Discussion	22

Appendix A- Attendees

Appendix B- Membership roster

Appendix C- Presentations

Appendix D- Agenda

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December 3, 2013

Welcome and Introduction

Incoming Science Committee Executive Secretary Ms. Deirdre L. Jurand opened the meeting and made administrative announcements. Ms. Anne Delo is the new committee support specialist.

Dr. David J. McComas, Chair for the NASA Advisory Council (NAC) Science Committee (SC), opened the meeting and welcomed new member Dr. Steve Running, who is the new chair of the Earth Science Subcommittee (ESS). Dr. Running briefly described his background as plant physiologist, and NASA experience in early global habitability issues and development of algorithms related to the global carbon budget. Dr. Doug Duncan was also introduced in absentia as a new member. Dr. Carlé Pieters has been named vice chair of the SC, and Dr. Eugene Levy has been appointed as a temporary vice chair to represent the SC to the NAC during the following week. Dr. McComas personally thanked former Executive Secretary Dr. T. Jens Feeley for his work on the SC. Science Mission Directorate (SMD) Associate Administrator (AA) Dr. John Grunsfeld was not present on the first day of the meeting.

Dr. McComas addressed the reorganization of the NAC, and favorably viewed the new ability of the SC to directly advise the SMD AA, without passing advice up and down the NAC chain of command. However, he noted that the present meeting results would be subject to previously applicable rules. Dr. McComas noted that he had spent some time with Larry Smarr to discuss a potential joint study with the Information Technology Infrastructure Committee (ITIC) of the NAC, and the intention to identify 2-4 SC members to serve on the study group. The IT committee under the NAC is being eliminated, however, so the status of this joint effort is uncertain.

Update on 2014 SMD Science Plan Status

Mr. Dan Woods presented a status of the Science Plan draft, and distributed a copy of SMD responses to comments from the various advisory committees. In early September, the editors moved the Heliophysics (HP) objective from the Earth to the Science goal, as previously advised, and also added space weather to the HP science goal. The National Research Council (NRC) has also reviewed the plan and has provided its feedback to NASA. Mr. Woods discussed Agency responsiveness to NRC guidance, much of which is associated with the transparency with which NASA addresses Decadal Survey recommendations. SMD has also been asked to provide more detail on how NASA determines the goals of the Science Plan. Some of this information is tied to embargoed budgetary particulars, so it will be challenging to discuss the internal mechanics of decision-making. SMD has also been asked to examine the role of the principal investigator (PI) in implementing science goals. NRC has asked for detail on how the cost, scope and complexity of major projects will be constrained within the current budgetary atmosphere. Dr. Levy commented on SMD's interpretation of the NRC's critique about decision processes, observing that the NRC was likely more concerned about principles underlying Agency philosophy, and not about who is talking to whom. Mr. Woods welcomed this interpretation, and felt these philosophical principles were well laid out in the document.

The NRC also recommended that NASA re-examine the science balance within limitations of the constrained budget. Dr. Grunsfeld has spent much time explaining this to senior leadership in recent months. Interdisciplinary aspects, collaboration with other directorates/divisions, better descriptions of the linkages between disciplines, as well as opportunities with NASA partners and outside the Agency, are all under discussion. The Education/Public Outreach (E/PO) office is actively working on what message the Agency wishes to convey to its audience. Asked what NASA is doing to preserve the E/PO program, Mr. Woods responded that he could not answer this question until budgetary decisions by Congress are made on the FY2014 budget. NASA is still operating under a continuing resolution (CR), and is still implementing the E/PO program as it has always been implemented pending further direction. NASA is in a holding pattern as a result of the CR.

Mr. Woods agreed that the Science Plan needed to spend more time articulating the integration of technology development with science in advancing missions. The Science Plan continues to work to align with the NASA Strategic Planning process, and will add details to the document, such as metrics of success. Further efforts will be made to improve readability and clarity, adopt a consistent voice, and provide a clear accounting of how the plan varies from past plans and Decadal Survey recommendations, including reasons for any deviation.

Next steps will include a presentation of NRC/Space Studies Board (SSB) recommendations to SMD management in mid-December. The next draft will be sent to the Office of Management and Budget (OMB)/Office of Science and Technology Policy (OSTP) late February 2014. The final Science Plan is due to be released directly after the FY15 Presidential budget release. Dr. Janet Luhmann asked about planning continuity from year to year. Mr. Woods noted that the NRC had recommended that SMD examine past plans and Decadal Survey recommendations, and how SMD has addressed these. Dr. Noel Hinners commented that the briefing details had successfully addressed many of the issues that SSB and Dr. Hinners had had with the Science Plan. Mr. Woods expressed willingness to send the newest version of the document (post-NRC) when it goes to OMB/OSTP, to give the SC a chance to catch anything egregious. Dr. McComas noted that he was still concerned with the Heliophysics objective, in that it needs to be more inclusive to avoid disenfranchising members of the community. He commented that it would be a mistake to define any one science area's/Division's objective narrowly compared to the other science area's/Divisions; Heliophysics is not just about the Sun and space weather; somehow the Science Plan still misses this key point.

SMD Budget Status

Mr. Craig Tupper provided an update on the budget, beginning with a summary of cost and schedule performance of missions in phase C, and launches over the past two years. The Lunar Atmosphere and Dust Environment Dust Explorer (LADEE) overran by 14%. The Mars Atmosphere and Volatile Evolution (MAVEN), LandSat Data Continuity Mission (LDCM) and Global Precipitation Measurement (GPM) missions are considered likely to actually underrun their numbers. ICESat-2 is unlikely to keep its cost commitment, however. The FY14 budget remains unchanged from the previous meeting, and still

shows a steady decrease through 2018. SMD remains at 25-30% of overall Agency budget. The FY13 Operating Plan, approved on 2 August, now stands at \$4781.6M for SMD. The FY14 sequestration assessment assumes NASA's overall budget at \$16.160B. It seems likely that at the very least SMD may get \$4.78B, and at most \$5.1B (between House and Senate mark-ups). Dr. Bradley Peterson commented that the James Webb Space Telescope (JWST) would be underfunded under such budget figures. Mr. Tupper noted that NASA could probably propose re-alignments. If sequestration were to last indefinitely, the SMD budget would be close to \$4.1B in 2018. Fiscal 2013 was the third lowest budget in 20 years.

Earth Science Division Update

Dr. Michael Freilich, Director of the Earth Science Division (ESD), gave an overview of the division, noting no budget changes since the previous meeting. Stability deriving from the Administration budget request over the last several years continues to be the case. Appropriations fell somewhat below the request due to sequestration, but this reduction was mitigated by "harvesting" efficiencies in programs. A balance between flight and non-flight activities is critical for Earth Science portfolio, and ESD has retained this balance despite changes. Non-flight missions and operations represent 30-40% of the budget at present; Dr. Freilich would like to get it to 50% eventually.

ESD continues to operate constellation of 16 Earth-observing (EO) missions from large to small; Jason-1 was terminated in June 2013, after a 10-year mission, upon the failure of a data transmitter. ESD conducted a Senior Review in Summer 2013 and has incorporated its results into the budget; the present constellation will continue. There have been some technical difficulties with some satellites, and ESD has assumed a ramp-down of costs in missions that may not last for 5 more years. Dr. Pieters asked about costs associated with terminations and their effects on budget planning. Dr. Freilich replied that all missions are asked to review their "phase F" termination plans and build them into the budget. Jason-1 was a French spacecraft and therefore CNES was responsible for end-of-mission disposal costs.

2014 will be a major year for launches. GPM is scheduled for early in the calendar year, the Orbiting Carbon Observatory-2 (OCO-2) for July, and Soil Moisture Active-Passive (SMAP) for November. The Gravity and Climate Experiment (GRACE) follow-on mission is scheduled for August 2017, Cyclone Global Navigation Satellite System (CYGNSS) for 2016-17, ICESat-2 for December 2016, and the Strategic Aerosol and Gas Experiment (SAGE)-III for March 2015. ICESat-2 has been having significant technical and programmatic difficulties, and will require a future baseline review to reset the appropriate costs and launch date. ESD continues to operate a substantive and large portfolio, which is fully funded. Dr. Luhmann asked if there were an orderly plan for retiring satellites as they reach the end of their mission lifetimes. Dr. Freilich responded that operations costs run on the order of 10% of the ESD budget, and that these costs are incorporated into mission planning.

Other missions in development for the far future include Pre-Aerosol, Clouds and Ocean Ecosystem (PACE), Surface Water Ocean Topography (SWOT), and L-Band Synthetic Aperture Radar (SAR). There will be 5 more launches in the constellation between 2017 and the end of the decade, all of which are funded. Future International Space Station (ISS) missions will include SAGE III, RapidScat, and LIS

(atmospheric imaging and lightning). Dr. McComas noticed an uptick of missions on ISS and asked why this was so. Dr. Freilich explained that within the ISS program, there is a new desire to demonstrate the value of the investment; there is an opportunity to fly, install and operate instruments at little or no cost to ESD. It is not the perfect platform for some instruments, but it is good from a cost-benefit standpoint. Dr. McComas asked if these missions could be flown on better platforms (i.e. satellites). Dr. Freilich felt that all but SAGE-III and OCO-3 could be done better on a satellite, but launch vehicle costs are prohibitive. ISS provides power and communication services, as well. Dr. Peterson noted that this is a change from past practices. Dr. Freilich agreed and commented on ESD's improved relationship with ISS.

ESD's Venture-class (EV) program remains fully funded. Venture-class comprises a science-driven, PI-led, competitively selected, cost-constrained set of missions that have been derived from high-priority Decadal Survey recommendations. The first fleet of 5 airborne investigations was selected in 2010, and these are well into their field campaigns. Solicitations must come out in a timely manner to sustain this program, thus ESD has adopted draconian approaches to managing missions. For the EV-1 Suborbital program, proposals are due in January 2014; the latest EV-M small satellite mission is the previously mentioned CYGNSS; and the EV-I instrument line has selected TEMPO for an early FY18 launch. The second EV-I solicitation was released in July 2013. Dr. Pieters asked whether the ISS ES missions have lifetimes. Dr. Freilich replied that due to ongoing use of various attachments on the facility, ESD missions are finite, but the disposal is on the HEO side; it is not certain whether these instruments will come back to Earth for re-use. Dr. Luhmann commented that in other divisions there is tension between strategic and PI-led missions- how is that handled in ESD? Dr. Freilich noted that ESD is well beyond the start-up phase on the Venture class missions. ESD has never seen Venture class as a way of getting around strategic recommendations from the Decadal Survey, but has broadened its philosophy to include strategic measurements.

Airborne science continues to operate a wide variety of aircraft to supplement ES missions. One of the Decadal Survey recommendations in 2007 had been to utilize airborne assets more frequently. ESD has increased airborne hours from 1000 to 2500-3000 flight hours per year, and is now pushing for 4000 hours annually. Multiple field campaigns are being carried out simultaneously. 4 September 2013 marked a record-setting day of 6 aircraft in deployment at one time. One of ESD's airborne science programs, the SEAC⁴RS campaign, includes DC-8, ER-2 and SPEC Lear jets. During 2013, NASA deployed 190 people in the SEAC⁴RS program over a seven-week duration, and successfully sampled images of fires in Yellowstone National Park and Idaho, agricultural burning, a North American monsoon, convective processes, tropical storms, and urban pollution. Other flight campaigns include LVIS Greenland, UAVSAR imaging, and Operation IceBridge Antarctica. Due to political volatility, there is no current plan to fly in Southeast Asia.

Dr. Freilich presented some science highlights: The SEAC⁴RS flight accomplished the longest survey of a single fire plume ever accomplished. Two NASA cubesats will launch on a National Reconnaissance Organization (NRO) vehicle on 5 December. The division also flew an ES instrument on a balloon, illustrating the synergies between divisions and directorates. During Typhoon Haiyan's impact on the

Philippines, NASA provided useful data to the Disaster Response Coordinator at the US Geological Survey (USGS) Earth Resources Observations Systems (EROS), enabling imaging of anthropogenic light (to indicate which areas were still blacked out) and radar-based assessments of storm damage.

NASA's "SI-OP-ERB" activities include responsibility for sustained measurements of Solar Irradiance, Ozone Profile and Earth Radiation Budget. The National Oceanic and Atmospheric Administration (NOAA) and Joint Agency Satellite Division (JASD) have launched the Total Solar Irradiance Calibration Transfer Experiment (TCTE), a gap-filler mission for solar irradiance measurements; there are also a number of efforts under way to keep all these measurements going on various platforms, such as JPSS-1, Suomi NPP, and NOAA's Free Flyer-1. In response to a question about absolute calibrations that underlie these measurements, Dr. Freilich described the stability of measurements as profound and that absolute calibrations have been rationalized over time.

For sustained land imaging, the FY14 budget is ramping up to accommodate NASA's responsibility to lead the architecture design and space component implementation of a sustained system for global land imaging, in tandem with the USGS. The effort is funded at roughly \$120M per year, for a system with a 20-year lifetime (2018-2038). An architecture study is under way, for which a Request for Information (RFI) was released in September. NASA received 35 inputs on 1 November. NASA and USGS will have a community workshop to communicate the architecture options in March 2014. Recommendations and an Implementation Plan are to be submitted to the Executive Office of the President by August 2014. Asked about a plan to replace Delta-2 launch vehicles, Dr. Freilich reported that ESD will hold competitive solicitations through the NASA Launch Services (NLS-2) contract. Currently, ESD has launch vehicles for all ES missions except SWOT. The division is looking at Falcon and Antares vehicles as reasonable substitutes for the Delta-2s. Jason-2, e.g., will fly on a Falcon 9.

Planetary Protection

Dr. Catharine Conley presented a status of the Planetary Protection Office (PPO), beginning with an overview of PP, which is intended to avoid contamination of extraterrestrial locations, preserve planetary conditions for future exploration, and to protect the Earth and its biosphere from extraterrestrial contamination. In recent years, far more data has been accumulated regarding the range of life on Earth in terms of habitability; there are some organisms on Earth (*Serratia* spp.) that can theoretically survive on protected areas on Mars. Of particular concern is the observation that space-exposed bacteria can become more virulent upon return to Earth (e.g., *Salmonella typhirium*). Planetary protection also occurs within an international framework that includes the United Nations, the National Research Council (NRC), Space Studies Board (SSB), and the Committee on Space Research (COSPAR), details of which are specified by the Outer Space Treaty. Dr. Conley described how PP policy decisions are made at NASA: The Planetary Protection Subcommittee (PPS) provides advice and recommendations to the NAC SC, which flow to the NASA Administrator, thence to the PPO.

Dr. Conley provided a description of how levels of protection are categorized for various missions. Planet Priority D objects include nearly everything in the Solar System. Mercury and Io, for example, are considered of little interest to PPO due to their hostile environments. Sample return missions that involve cometary materials and solar wind are considered to be “unrestricted Earth return,” categorically. Possibly hospitable environments are thought to exist on Mars, Enceladus, and Europa, and therefore the Agency places appropriate constraints on returned samples. For Mars, returned samples are to be treated as potentially hazardous until proven otherwise. Materials returned from ISS are not considered extraterrestrial, by the terms of the Outer Space Treaty. In response to a question, Dr. Conley noted that China has signed the Treaty and is presumed to be following protocol associated with the treaty in their space exploration missions.

Dr. Eugene Levy reported on the latest deliberations of the PPS, and noted that the subcommittee was not bringing forward any recommendations to the SC. The Mars 2020 mission occupied much agenda time at the most recent meeting of PPS. Mars 2020 is intended to build on Mars Curiosity heritage; the 2020 mission will gather and document a cache of samples capable of being retrieved by a subsequent mission. This raises obvious PP issues, as samples must be sealed before they can be returned to Earth, and will give rise to a specific set of PP requirements, especially if the 2020 rover contacts “special regions.” Dr. Levy pointed out that these PP requirements derive from international regulations under COSPAR, etc. and that COSPAR has recently slightly altered the language that deals with life detection missions; PPS has recommended that NASA adopt the new language to reflect a more flexible approach to meeting PP requirements.

The Mars 2020 mission is still in its definition phase, but the PPS feels strongly that appropriate PP requirements/measures be built into the mission from the earliest stages of development. In addition, a PPS recommendation to meet with the European Space Agency (ESA) for joint PP meetings, while initially implemented by NASA, is now in a state of failure, as NASA seems unwilling or unable to implement the agreement.

Discussion

Ms. Jurand provided clarification to the chain of NAC advice, in that PPS does not make recommendations to the PPO, it actually makes recommendations to the NAC. Dr. Hinnners commented that a recent Mars Science Laboratory Lessons Learned (MSL LL) report contains many relevant recommendations with respect to PP issues. Dr. Maura Hagan expressed concern with excessive travel restrictions that have begun to greatly hinder meetings with NASA’s partners. Dr. McComas commented that the SC may want to address the issue of travel restrictions more specifically.

The SC took up other topics of discussion, such as a new process for how travel is approved, and the current status of NASA E/PO. Dr. Hinnners observed that perhaps the SC might want to improve its input into the early draft process of the Strategic Plan. Dr. McComas felt that NASA had been basically responsive to SSB/NRC comments, and that the SC still has the opportunity to comment further on the SMD Science Plan. Dr. Pieters felt that the committee didn’t have a chance to judge whether NASA was

interpreting the critique properly. Dr. Levy thought the matter should remain between the NRC and NASA. Dr. McComas suggested that Mr. Woods meet with the NRC to confirm that the critique is being interpreted correctly.

The SC addressed travel issues in greater detail, in response to the shared perception that the science community is increasingly curtailed by new restrictions. There is a general sense that travel restrictions are inhibiting NASA employees from doing their jobs. Dr. Hagan felt the problem was endemic to the federal government. Dr. Steve Running commented that NASA program managers have been prevented from attending conferences even if it incurs no cost to NASA, pointing to an issue of appearance. Dr. Peterson noted the Astrophysics Subcommittee (APS) did weigh in on the subject at its April meeting, and made recommendations to NASA to relax restrictions as soon as possible. Dr. McComas agreed that people must be permitted to gather together to carry out the scientific enterprise. Dr. Peterson said that the public thinks conference travel and attendance is a perk. Dr. Pieters suggested the SC reiterate the importance of person-to-person contact. Drs. Pieters and Running took up the task to write a committee finding. Dr. Hinnners commented that the travel problem originated in Congress, and that it might be useful to promote better use of videoconferencing, while reinforcing the utility of face-to-face interactions. Dr. Levy reported having had very good virtual meetings in adequate conferencing facilities, but that they are not a very good replacement for real meetings. Dr. Pieters agreed that virtual meetings do have their place, such as one that the Lunar Science Institute had held during the previous summer. They pulled it off, but feedback substantiated the present conversation. Dr. Levy felt that a move to all-virtual meetings will produce significant stagnation. Dr. Hagan remarked that NASA should not be too risk-averse in implementing travel advice coming from the White House/Congress. Dr. McComas agreed that there have been uneven and locally more conservative interpretations of rules (i.e., at some field centers).

Astrophysics Division Update

Dr. Paul Hertz, Director of the Astrophysics Division (APD), briefed the committee on the status of the division. The budget is at a high level, the James Webb Space Telescope (JWST) remains on schedule and is fully funded for a 2018 launch. APD is working with international partners, preparing two new Explorer projects to begin development in this decade, and preparing for the next strategic mission to follow JWST. The budgetary future remains uncertain, but the Decadal Survey will guide future priorities, while maintaining core programs. A number of science definition teams (SDTs) are working on strategic mission concepts such as WFIRST, exoplanet probes, and an x-ray probe. The SDTs will provide interim reports to the Committee on Astronomy and Astrophysics (CAA) and NASA in early 2014 and final reports in early 2015. This activity is taking place in the context of ESA's L2/L3 mission planning.

Major impacts of the government shutdown to APD include the cancellation of the 2013-2014 Antarctic balloon campaign including the cancellation of 3 long-duration balloon flights (SPIDER, BACCUS, and a Super Pressure Balloon 100-day test flight). Three flights are planned for next year, which will require prioritizing long-duration balloon (LDB) payloads. The Stratospheric Observatory for Infrared Astronomy (SOFIA) cancelled nine science flights with US instruments, but it is re-scheduling the

commissioning of FLITECAM, delaying the full operational capability (FOC) milestone by one month. Assessments are ongoing to determine other impacts.

The latest assessment of Kepler data suggests that the spacecraft has detected about a dozen Earth-sized planets where water might exist at the surface. Kepler has lost two reaction wheels and retains two remaining wheels; APD put out a call for white papers for a “K-2” mission and received 42 papers in response. A report on the potential “K-2” mission has been submitted to HQ and is being independently reviewed; NASA is prepared to make a decision soon on whether “K-2” will be sent to the Senior Review. A Senior Review will be conducted for operating missions; the call for proposals took place in November 2013. APD continues to assess the potential use of 2.4m telescope assets for the purpose of carrying out the science goals of the Wide-Field Infrared Survey Telescope (WFIRST). The study concept is called AFTA (Astrophysics Focused Telescope Assets) and will be a subject of an NRC study in early 2014 to determine whether a mission of this type is responsive to the Decadal Survey. APD is also considering a coronagraph and is in the process of downselecting six coronagraph technologies to two. The intent is to have two at technology readiness level 5 (TRL-5) by 2017. In the meantime, ESA’s L2 mission decisions have been made. APD continues to preserve funding in its Research and Analysis (R&A) program; selection rates this year are at 15%. Some of this low selection rate has been driven by the growth of the number of proposals. APD is exploring ways to raise the selection rate, including consideration of two-step proposal models and limiting the number of proposals people or institutions may submit. It is clear that APD must change its way of doing business, however, in order to change the selection rates. The committee discussed varying modes of proposals, noting that APD has not yet experimented with two-step modes.

The FY13 appropriation for APD ended up at \$42M lower than President’s budget request, thus APD has made reductions that summed to that total, accomplishing this by mostly one-off tasks. Unneeded FY13 reserves have been re-phased for developing missions, and development of current and future Explorers has been slowed. The reduction will result in some liens against 2014. JWST remains the highest priority mission, such that further reductions will come out of other areas in APD. Dr. Hertz has recommended fully funding JWST in 2014, despite an approximately \$70M shortfall, representing the difference between the President’s FY14 request and the House budget mark-up. This is about a 10% effect on the rest of APD. Dr. Hertz noted that 2014 is the peak year of funding requirements for JWST. Upcoming missions for APD include Astro-H, ISS-CREAM, and NICER, and APD plans to release a Small Explorer (SMEX) call for 2014 and an Explorer in 2016. The ESA Euclid mission is scheduled for 2020. APD will have about a launch per year in the next decade. Dr. Hinners commended the idea of a Cost Analysis and Technical Evaluation (CATE) for WFIRST, and asked if there was a budget target yet. Dr. Hertz reported that the division is exploring many options and prioritizing missions. At the moment, WFIRST has an optional coronagraph, and notional orbits and mission lifetimes, giving some flexibility to the potential cost of the mission; these will require some refinement before such choices can be made.

Dr. Bradley Peterson, Chair of the Astrophysics Subcommittee, briefed the committee and noted that he carried no actions from APS. He presented the status of the Astrophysics Roadmap, which was

established in February 2013 to build on the 2010 Decadal Survey. The Roadmap is addressing scientific and technical challenges and soliciting public input. The Roadmap team was selected to provide a range of expertise, as well as diversity in age and gender. The team has met on two occasions and is conducting the remainder of its work by teleconference. Community input consisted of 82 science abstracts and 24 technology abstracts. The Roadmap team held a two-day virtual Town Hall meeting in May 2013, and created its penultimate draft in early November. The draft was discussed extensively in the last APS meeting; the final copy is due to be released by mid-December. APS would like to present the Roadmap to NASA as input for future strategic planning. It is hoped that the Roadmap will provide a compelling 30-year vision that is science-based, with notional missions. The Roadmap addresses the three main quests of Astrophysics: How does the universe work, how did we get here, and are we alone?

The Roadmap addresses missions that explore the full diversity of planetary systems, decode the assembly of the Milky Way galaxy, and look for imprints of the Big Bang. The theme encompassing the search for life includes measuring the frequency of potentially habitable planets, characterizing, and identifying and mapping the most promising exo-Earths. Activities in the Roadmap are divided by era: present, near-term (2020-2030), formative (2030-2040), and visionary (2040-2050). There is a section on public engagement, as well as cross-cutting or game-changing technologies, and new materials. Interferometry challenges such as precision laser metrology, formation flying, beam combination, and aperture synthesis techniques are also discussed. The document addresses daring visions, such as sensing ripples in gravity out to the edge of the Universe; charting the warped space of black holes; telling the complete story of galaxies, reconstructing the complete star formation, structural and chemical history of the Milky Way and its neighbors; and mapping the surfaces of Earth-like exoplanets. Dr. McComas suggested renaming the Roadmap to a “Vision,” as the word “Roadmap” has certain implications for NASA. Dr. Peterson characterized his presentation as information-only.

JWST Status

Dr. Eric Smith provided a status of JWST. The upcoming year of 2014 marks the year of manufacturing the spacecraft. The program has continued extensive communications on a quarterly basis with OSTP, the Hill, and contractors. Members of the SRB are regularly invited to Flight Program Reviews. Earned Value Management (EVM) data are being received from industrial partners; cryocooler EV data has been flowing to the project, where an integrated master schedule will enable more detailed reporting within the next months. The project has had reviews with the IPAO, and participated in the GAO exit conference for 2013. All flight instruments are now at Goddard Space Flight Center (GSFC) and have undergone the first Integrated Science Instrument Module (ISIM) cryovacuum test; this test was interrupted by the government shutdown. Testing was stopped but the ISIM stayed at cryogenic temperatures, thus the test achieved risk reduction activities despite the interruption. Replacement detector manufacturing is a year ahead of schedule, addressing an issue with a new infrared (IR) spectrograph, which is a microshutter device. Some shutters had been seen to be sticking during vibration tests; the first array succeeded, and the second failed. The project is working on this within schedule. Fifteen of 18 primary mirror segments for the optical telescope segment have shipped to GSFC, and the remainder is due by the end of December 2013. The backplane center section and support frame have been mated. All sunshield

engineering template layers have been delivered, and actual sunshields are now being manufactured.

Dr. Smith reviewed various fiscal 2013 milestones. The Cold Head Assembly was delayed to December, but will arrive in time for a second cryovacuum test. A Sunshield membrane cover manufacturing readiness review has been delayed. Fiscal 2014 HQ milestones were delayed somewhat by the shutdown. The spacecraft Critical Design Review (CDR) has been moved back a month (December 2013 to January 2014; however 2 other milestones were completed early). Primary Technical Performance Measurements (TPMs) include meeting requirements for thermal parameters, which will continue to trend close to the margin. The Program Manager Watch List's top concerns are definitization of an NGAS contract modification and low FY14 unencumbered Unallocated Future Expenses (UFE, or reserves). The cryocooler has a very low schedule reserve. Cold head assembly cryogenic valves were found to be leaking at one point and had to be re-designed, contributing to the problem. There were also welding issues with the cryocooler compressor assembly (CCA). Other issues to watch are fabrication of replacement detectors, microshutters, ISIM integration and test flow, non-explosive actuator shock generation (which had required a re-design), and mid-IR stray light (solved by placement of a baffle). The project has plenty of mass margin at this point.

Scientific concerns remain, such as the sensitivity of mid-IR performance and small changes in observatory component design. Thermal modeling will likely always be a concern; and the sunshields can also affect optical performance by way of potential excessive heat. E/PO issues have been solved; all E/PO activities are housed at Space Telescope Science Institute (STScI) in the Office of Public Outreach. Funding is at \$900K for FY14, after having been re-allocated within the JWST budget.

Dr. McComas noted that the NAC was seeking more information on launch vehicle reliability for JWST. Dr. Smith described the outcome of a Launch Vehicle Technical Interface Meeting (TIM), which took place in November in France. Ariane has the most successful launch history to date in terms of vehicles currently in production, higher than any US launch vehicle. Both ESA and NASA will be involved in housing the telescope before launch.

Discussion

The SC provided feedback to Dan Woods on the Science Plan, trying to get to the guts of what is shaping the programmatic, given budget difficulties. Mr. Woods addressed the problem of how to present a structure for the decision-making process. Dr. McComas recommended that Mr. Woods touch base with the NRC ahead of the scheduled meeting to confirm that the communications have been clear.

Dr. Mark Robinson raised an issue of concern to some in the planetary science community, namely the reorganization of research programs at NASA.

Dr. McComas noted the uneven application of E/PO funding across SMD, in that E/PO funding had been restored in some divisions. Dr. Jens Feeley commented, noting that NASA is still operating under the FY13 CR, and must continue to do what it had been doing previously. It is not clear what the ultimate

determination of the 2014 proposed changes in E/PO will produce. JWST and ESD happened to have the funding and went forward with their previous plans, but each of the divisions had been required to plan around the interim CR conditions, as well as to create contingency plans for disappearing money in 2014. Dr. McComas worried that E/PO would become very uneven over NASA, and felt it imperative to restore the outstanding E/PO work that has been accomplished across the Agency.

December 4, 2013

Planetary Science Division

Dr. James Green presented a status of the division. PSD has begun working with the Human Exploration and Operations Mission Directorate (HEOMD) under the auspices of a revamped institute (Solar System Exploration Virtual Institute; SSERVI), which has been re-chartered to focus on science that enables HE, with shared funding between PSD and HEOMD. Solicitations and evaluations have been held, and teams have been selected and awarded \$1M each. Programmatic balance is the goal of this new institute, and contracts are under way at Ames Research Center.

PSD is in the process of restructuring planetary R&A, in response to the NRC report, *Enabling Foundation for NASA's Earth and Space Science Missions* (2010). PSD held an internal retreat, and an open Virtual Town Hall meeting (3 December) on the restructuring. The NRC had recommended that SMD mission-enabling activities be linked to the strategic goals of the Agency and of SMD. NASA's response was in complete agreement with this recommendation, and therefore the Agency is seeking to explicitly tie SMD's Research Opportunities in Space and Earth Sciences (ROSES) to their broader strategic goals, including those involving HEOMD. Former Planetary Science Subcommittee (PSS) Chair Ronald Greeley and former SMD AA Ed Weiler formed a working group (WG) to perform a review to this end, using the NRC report as a guide for the study, to map mission-enabling activities to PSD's strategic Science Plan, and provide recommendations regarding "active portfolio management." The WG found that due to overlap in R&A programs, and the increased workload on program management officers and the community, PSD should consider consolidating programs to eliminate overlap. PSD is now re-focusing its R&A program. New core research programs have been created. These are: Emerging Worlds, Solar System Workings, Habitable Worlds, Exobiology, and Solar System Observations. Emerging Worlds maps to Origins of Solar Systems and Cosmochemistry. Solar System Observations correspond to Planetary Observations and Near-Earth Object Observations, in terms of ROSES calls. The restructuring is meant to create new cross-disciplinary opportunities within the available budgets. Exoplanets, for example, will be jointly funded by both PSD and APD. Core programs have wide scopes and address division science goals; strategic programs address strategic needs; focused programs are narrow in scope and time-limited, a year or so in duration. Some examples of focused programs are ETIPS (emerging topics) and LDAP (lunar data analysis). Comet ISON observations are a good example of an ETIPS topic. Two core technology programs are PICASSO for low-TRL instruments, and MatISSE for higher TRL instruments.

Each PSS Analysis Group (AG) has been coordinated to collect questions from the community. There are larger questions on conflict of interest and how to handle a larger (in both scope and proposal load) R&A

program. APD's large Astrophysics Research and Analysis (APRA) program has been proven to work effectively; it gets reviews done and the money out. PSD calls will emulate APRA and will be run by several program officers. PSD is now planning to draft calls and post them online for comments; the next call for ROSES in February 2014 will have this new structure. Dr. Pieters noted that some details of the reorganization are still fuzzy, e.g. habitable worlds, exoplanets, astrobiology overlap. Dr. Green acknowledged having had questions about it, and noted proposers must be clear about where they should propose. All topics come from previous ROSES calls, the language will be there, and the community will provide input regarding the call language. PSD would prefer not to delay the new structure and will hold a "peer review" at the end of each call to assess how to make changes for the next call. In response to a question on time and cost, Dr. Green conceded that the community would probably not write fewer proposals. He also noted that because of the reorganization, some proposers could face a longer-than-usual gap in their proposing cycle that may need to be addressed with assistance from program officers on a case-by-case basis. Dr. McComas advised Dr. Green to emphasize efficiencies gained through consolidation. Dr. Marc Allen commented that the restructuring should be envisioned as a population of investigators looking for grants, and therefore should be neutral to proposal effort. Dr. McComas said that the community is better off doing science than sitting on panels, and called for some calculation of how many people sit on panels, their time expended, etc., compared to the research funding being distributed. Dr. Green stated that the PSD does have such statistics, which could be further mined and presented.

Dr. Green described numerous planetary science mission outreach events that had taken place over the previous year. LADEE launched on 6 September, and is now in science orbit with instruments up and running. The mission's laser technology demonstration worked spectacularly well, providing an order-of-magnitude better air recovery than anticipated, and showing it could transmit through thin cloud cover. Large volumes of data via laser transmission occur in seconds rather than hours. There were more than 50 official launch viewing events for LADEE, including broadcast on the Toshiba board in Times Square, NY. MAVEN was launched on 21 November; its instrument checkout is to take place shortly. WISE has been reactivated to function as an NEO detector, viewing in the infrared. Cool-down will take up to 3 months before effective operations can begin. An AO for instruments for the Mars 2020 mission has been issued; proposals are due 15 January. The next Discovery AO has been initiated. PSD has received 57 responses to a request for information (RFI), which is now closed and in the process of analysis. The division is considering an additional Town Hall meeting, and wants the draft AO out by this fiscal year.

Suborbital flights for PSD include its first major balloon flight in some decades, to study comet ISON. This project, BRRISON, had an anomaly, but PSD was able to recover the payload. Comet ISON observations were also carried out on a rocket, FORTIS, which imaged ISON with a far-UV spectrometer, successfully. Data is being analyzed. A White Sands rocket was also launched to collect data on the deuterium-to-hydrogen ratio on Venus.

Dr. Hinnert asked whether it was possible to operate both Cassini and MSL in 2014. Dr. Green replied that PSD has the same amount of money for extended missions (EMs) this year as is planned for next year. Next year, there will be a Senior Review to make this determination. A lot of community input will

be needed on how to manage this competition and future EMs.

Dr. Janet Luhmann, Chair of the Planetary Science Subcommittee (PSS), reported on the subcommittee's latest deliberations, noting that PSS has suffered from a lack of face-to-face meetings. During a Webex meeting on 5 November, PSS heard a brief summary of the R&A reorganization, and raised the subject of a highly stressed community, coupled with the budget situation that exacerbates the problem of unknowns. The Town Hall meeting on the R&A reorganization was necessary and somewhat effective in getting information out in a clear way that also permitted feedback. The AGs were very effective in getting information out and filling in the broader communication gaps. Dr. Luhmann felt the Town Hall meeting had been very effective in its effort to inform the community of what to expect regarding the next ROSES call but there is still widespread consternation and uncertainty. Solar System Workings will not be due until February 2015, leaving some people are worried about the temporal gap in funding for this area. Other topics addressed during the Webex included the PSD status, and government performance grading.. PSS continues to be concerned about budget shortfalls, restoration of mission opportunities, and the future of the proposed Europa Clipper Flagship mission. While the Clipper now has an instrument development AO, the next steps toward this mission are unclear. Near-term concerns for PSS will be the reorganization of the R&A program, and using the existing budget more effectively to enable science. PSS also expects to see increased pressure on the EM line with MSL rolling on and Cassini still present in the EM queue.

Science highlights

Remarking that the AGs have been effective getting the science out to the public for sharing, Dr. Luhmann presented recent science findings. Cassini has found that tidal forces control the jets of Enceladus, as its geological activity varies systematically as the moon progresses through its orbit. A finding was released on the methane lakes and seas of Titan; there is apparently a great deal of surface tension with the atmosphere, yielding the potential to whip up large waves and cyclones. Imagery of recurring slope linea on Mars indicate that shallow water may be abundant near the surface in equatorial regions. New spectral data on Phobos/Deimos may also reveal bound water on these moons, which might have implications for in situ resource utilization (ISRU). ESA's Venus Express spacecraft has documented dramatic changes over ten Venus years, including a 30% increase in the speed of super-rotating winds, and tenfold changes in mesospheric SO₂ abundance. Auroras have also been observed on Venus, apparently in response to coronal mass ejections (CMEs). Lunar Reconnaissance Orbiter (LRO)-LAMP spectra taken in the UV range has yielded more details on the constituents of the lunar atmosphere, with indications of both helium and neon. LRO Lunar Diviner has been imaging Earth to support "Earth as a Planet" study resources. The Chelyabinsk incident of February 2013 is now being used to produce detailed computer simulations of impacts. Comet ISON seems to have disintegrated after reaching perihelion on 28 November, and was imaged by numerous NASA assets including Solar and Heliospheric Observatory (SOHO), Solar Dynamic Observatory (SDO), Solar TERrestrial RELations Observatory (STEREO), and possibly MAVEN. Ongoing analysis of Stardust data has identified 7 grains that appear to be interstellar.

MSL Lessons Learned Study

Mr. Mark Saunders presented the results of a Mars Science Lander (MSL) Lessons Learned (LL) study, chartered by the Office of the Chief Engineer. The study was undertaken to understand the reasons behind the launch delay, as well as the cost and schedule growth that characterized MSL. In addition, the study addressed Planetary Protection (PPO) aspects of the mission that resulted in a late re-categorization. The MSL team had a wide diversity of experience and perspective, which helped to drive a good outcome.

Mr. Saunders provided a brief history of the mission. MSL started out as a smart lander technology demonstration; its science content was greatly expanded in 2001. The mission failed its first Mission Confirmation Review (MCR), at which point it was estimated at \$1.4B. The project was asked to re-do the MCR, and it made major changes to system design in the process. Costs gradually grew to \$2.5B by late 2011. The LL team's opinion is that by 2003, MSL was already a Flagship-level mission in that it had eight to 10 instruments, a brand-new Entry, Descent and Landing (EDL) system, a novel sample handling system, a rover five times the size of the Mars Exploration Rover (MER), and a need for significant technology development. The process the mission used for matching scope and resources was flawed from the beginning. No one was looking at the mission from a critical perspective, and management never really bought into the increasing scope. For 14 months, the mission focused on an unworkable concept rather than performing necessary technology and engineering. The LL team believes the Agency could have known that the scope and budget were mismatched, either through independent assessment, or by historical comparison with previous Flagship missions.

Why didn't we know? The Jet Propulsion Laboratory (JPL) probably knew in 2006 that MSL was likely to slip, but did not announce this until 2008. Scope defines what the mission is going to cost. The formulation schedule was constrained, the architecture was unstable, and most of the systems were not at maturity. The project passed its CDR without adequate formulation; they essentially got a pass. Mr. Saunders remarked that during his tenure at IPAO, he didn't think any missions fully passed their life cycle reviews (LCRs). As a result of this observation, one of the team's main findings is that the Agency stop passing missions on inadequately met criteria. MSL also took a while to get its risk management practices in order, and delayed many important decisions that impacted its ability to get to its goal. Oversight was inadequate: Both JPL and MSL program offices were understaffed, reporting was inadequate, and the project never fully met any LCR criteria. While independent review teams did find issues, none of these were aggregated into overall assessments; accordingly, senior management was unable to understand the full impact to cost and schedule.

There are seven findings and 30 recommendations in the report, and five findings that are specific to the Mars 2020 mission. Finding 1 states that the Agency has a historical culture of underestimating missions. A key recommendation stemming from this finding is that NASA, SMD and the project should evaluate the degree of scope, complexity and risk for every directed mission at MCR, and that Mission Directorates should perform independent, non-advocate CATE-like reviews at MCRs. After such reviews, the project should adjust scope and resources if mismatches are identified. If a payload has not been selected by MCR, the project should conduct a delta-MCR and CATE-like assessment once again.

Finding 2 states that MSL did not satisfactorily complete Formulation by project Preliminary Design Review/Key Decision Point C (PDR/KDP-C) and arguably until after CDR. The concomitant recommendation is that projects should develop Formulation plans to satisfy Formulation criteria. Findings 3 through 5 deal with various aspects of mission oversight, management, and the imperative need for independent cost and schedule estimates.

Mr. Saunders highlighted the study's Planetary Protection (PP) Finding 6, which states that as a discipline PP does not follow classic systems engineering and project management processes. The resulting recommendation is to evolve PP to follow these practices accordingly. PP requirements should be written into the Level 1 requirements, which will then automatically flow down to the verification and validation (V&V) process. PP specifications also need to be less ambiguous about what recontamination really is, and the PP document NPR 80210.12, which elucidates these definitions, should be sharpened to reflect this. The SMD Handbook should be updated to reflect the PPO's responsibilities and the relationships among PPO, SMD, the Program and Center staff. SMD should also reconsider the current PPO location to ensure that PP is fully independent of any operational division.

Finding 7 states that Lessons Learned and best practices were not fully embraced by the MSL project and the Agency itself. As a result, the team recommends increased exposure to Lessons Learned activities and more workshops. As to Mars 2020, the team recommends that SMD implement the recommendations of the MSL LL study, fill the Mars Exploration Program (MEP) Program Director position immediately. Further, the study recommends that NASA ensure that the 2020 mission meets its cost and performance targets, maximize MSL heritage, selects a minimum payload, and constrains non-SMD add-ons. Mars 2020 must also be accomplished with the recognition that it is a mission that represents the first step in Mars sample return.

Dr. McComas commented that he was personally stunned at the magnitude of oversight throughout his own small mission in 2004-8, and wondered how such oversight could have been lacking for MSL. Dr. Peterson attributed lack of oversight to a "too big to fail attitude," which has also plagued JWST; management was not listening to people with boots on the ground. David Schurr, Deputy Director for PSD, noted that missions are allocated to centers, which are treated as if they have expertise to manage. Dr. Luhmann observed that in strategic missions, there are SDTs that meet to define these details. Mr. Saunders noted that MSL pretty much flew what the SDT had defined in 2001, but the delivery system had not been defined. He added that he thought that the Agency didn't quite get it, JPL included, and needed to step back and understand how difficult it was, and to manage future missions of MSL's magnitude appropriately. Dr. Levy expressed concern at Administrator Bolden's recent comments regarding Flagship missions and how they are no longer in reach, and how the community must think about the implications for NASA in the long run. Science objectives dictate the size of missions. It must be recognized that the planetary community can't conduct surface operations on another planet, and for astronomy, can't do another large telescope. He expressed further concern that we not end up gerrymandering ourselves out of the exciting science NASA has been doing for decades. The SC requested a full report from the MSL team.

Administrator Drop-in

NASA Administrator Charles Bolden dropped in to speak with the Science Committee, offering an exhortation to the community to become innovative and imaginative in response to the budget-constrained environment. As the Agency cannot support \$1B+ Flagship missions, it will be necessary to focus more on cadence; SMD needs to fly more frequently and focus on science objectives, and avoid eternal battles with OMB. The Agency is currently looking to send humans beyond low-Earth orbit (LEO), and has handed off LEO to Space X and Orbital commercial entities. Are they strong enough to survive the first accident? NASA must plan for re-grouping after inevitable accidents. How do we accomplish the same objectives, more innovatively, and more rapidly, within smaller packages? There is exciting work being done with cubesats by college students. As an example, NASA just launched a Minotaur with 29 cubesats, one of which had been created by cadets at West Point. Recently SMD's Jim Adams visited South Africa to collaborate on an asteroid initiative, which included some Science Technology Engineering and Mathematics (STEM) opportunities in education. NASA must do more of these types of activities to engage academia, public, industry, and the international community. Mr. Bolden encouraged members of the committee to provide feedback to the Agency.

ASRG Case Study/ ASRG Project Realignment Decision

Mr. David Schurr provided background information regarding cancellation of two Advanced Stirling Radiosotopic Generator (ASRG) flight units, which had been under development for about 10 years. The ASRG project was attempting to move to a more efficient radioisotope-based power system, converting heat to electricity. In 2009, a flight project was established to develop two flight-qualified units with the Department of Energy (DOE). Due to changes in requirements, difficulties with technology and manufacturing, schedule pressures, and budget limitations, the project has grown in cost and schedule. The cost-to-go is now \$175M, exceeding the FY14 baseline by \$100M, and the ASRGs could cost \$25M per year to maintain after initial delivery. The flight project had not undergone a lot of independent review, and had never been through a KDP review at NASA, nor through any similar review at DOE, thus the costs had not been rigorously estimated. Due to tighter fiscal restraints, and the fact that there are no Flagship-level missions in planning that would require ASRGs in the FY14 request, the existing ASRG flight project has been cancelled. The cadence of Discovery and New Frontiers announcements will be slower of necessity, and Pu-238 will be sufficient to support the lower cadence, thus relying only on MMRTG technology.

PSD will maintain the infrastructure, technology, expertise, and production for the Nation's Radioisotope Power System (RPS) capabilities. PSD has also directed DOE to terminate the existing ASRG flight project and has also directed the RPS Program Office to develop options to continue Stirling engine research as a technology development project. The plan is to incorporate residual ASRG hardware into a Stirling test project at Glenn Research Center (GRC), continue work on Stirling technology with respect to risk reduction, and conduct studies to determine optimal power levels for a next-generation Stirling Isotope Generator. Implications to future missions are minimal. ASRGs were not yet qualified, but any remaining technical issues are thought to be solvable given time and money. Some unique planetary

missions were identified for ASRG use. The termination of ASRG affects more proposed than actual missions; some proposed missions will be able to adapt to MMRTG technology.

Discussion

The committee took up findings on E/PO, and on Planetary Protection issues stemming from the MSL LL finding #6. A committee finding on R&A program reorganization was tabled until the next meeting. Dr. Running raised suggestions for improving proposal review mechanism; the Committee decided to hold a briefing on proposal reviews at the next meeting. Dr. Luhmann suggested adopting MSL Lessons Learned to improve center oversight, comparable to that which is performed for competed missions. Dr. Hinners commented on the cancellation of the ASRG flight projects, stating that something must have gone very wrong to have derailed a decade-long program. Dr. McComas suggested the Committee recommend that an internal ASRG team carry out a Lessons Learned study. Dr. Luhmann noted the lack of planetary mission opportunities and wondered how attention might be directed to the situation. She further questioned whether NASA could create small X-prize-like interdivisional science mission opportunities. Mars 2020 is really an Agency mandate, and is tying up resources while not necessarily addressing DS priorities. Dr. Hagan agreed, adding that the Heliophysics community is echoing these issues, and felt it would be a mistake to not comment on the current situation's negative impact to the NASA portfolio. Dr. Hinners felt it might be useful for the SC to get a look at what the entire Mars exploration program looks like in terms of sample return planning. Other members expressed mixed opinions about the value of carrying findings on Flagship-level missions.

Dr. McComas finalized writing tasks on findings: travel, Planetary Protection, and E/PO. Proposal review mechanisms and Mars 2020 issues were to be addressed at the next meeting. A request was carried forward to arrange for an ASRG internal LL briefing at the next meeting as well. The SC deferred a finding on MSL LL.

The committee discussed a finding on SMD's ability to carry out small missions. Dr. Levy felt the committee could appropriately address mission balance, and suggested acquiring more information about cost, balance, and mission planning. Dr. McComas thought this request could take the form of a letter to SMD AA. Dr. Luhmann commented that there are low-cost Discovery mission concepts, such as the early case of Lunar Prospector, that could provide desirable science and an affordable new start at these constrained budget times.. Dr. McComas proposed that Tim Van Sant and the Chief Technologist give a status at the next meeting. Dr. Pieters suggested that the committee plant the seeds to create more ways to carry out missions. Dr. Luhmann recommended sheltering the low-cost mission line in a way that some R&A programs are preserved. Dr. McComas agreed to seek more data on these matters via briefings at the next meeting.

Discussion with Science Mission Directorate Associate Administrator

SMD AA John Grunsfeld joined the committee for a discussion, and thanked members for serving the community. He expressed a preference for the new reorganization and remarked that SMD is still the most productive organization possible, and that new cost estimate regimes have been valuable.

It is hard to plan in the current environment, as there is a trend to more applied research. NASA makes tremendous contributions to the economy, and to inspiring young people, all of whom need to understand science. Asked how the community could change its behavior so that the MSL Lessons Learned recommendations will be heard, Dr. Grunsfeld commented that these Lessons Learned were relevant to the Hubble Space Telescope back in the 1980s. There are fundamental dynamic differences between center and multicenter efforts that have no PIs associated with them, versus an institutional, PI-led mission. Should we ask the NRC to look at these differences? He thought personally that PIs can build experiments, which scales well to a certain point. PIs don't have project management experience, however. Perhaps it would be fruitful to get Systems Engineering and Program Management practices into the graduate and undergraduate curriculum. About \$500M of the additional cost for MSL was technical, and the planetary window cost another \$500M. Somewhere in the middle, there was pressure from both ends. Dr. Hinners asked if there were any hope of filling the MEP Program Director position. Dr. Grunsfeld replied that there was some hope, but the Agency has a Civil Servant ceiling at the moment, imposed internally by Headquarters. Dr. Luhmann asked if there were any creative ways across SMD to create small-class mission opportunities. Dr. Grunsfeld expressed his concern about the New Frontiers program, and has asked PSD Director Jim Green to think about hybrid and Discovery-plus or New Frontiers-plus missions to address what formerly would have been called Flagship level missions: can you fit Europa into a New Frontiers-plus envelope? Dr. Peterson noted that the Astrophysics community feels that the current Explorer cap is too low. Dr. Grunsfeld thought that launch vehicle costs would drop over time, and that the community should look at some ways that the ESD conducts its Venture-class program. He remained open to ideas. As to whether E/PO would be conducted by the mission directorates, the Agency or by external agencies and organizations, he didn't know the answer, but conceded that NASA is losing the thread.

Heliophysics Division Update

Newly arrived Heliophysics Division (HPD) Director Dr. Dave Chenette showed some SOHO and STEREO views of the comet ISON to begin an overview of the division. Twenty NASA assets watched ISON as it approached. Dr. Chenette reviewed recent media coverage of Heliophysics, including the van Allen Probes and a major accomplishment represented by having Ed Stone interviewed on the Colbert report, speaking about Voyager-1 entering interstellar space. HPD also created various media opportunities with the launch of IRIS in June, with spectacular images and simultaneous spectra that revealed complex dynamics on the Sun, providing a complementary "microscope" to SDO.

Accomplishments and updates for 2013 included completing the first BARREL campaign in Antarctica, a balloon-complement to the van Allen probes. The Magnetospheric Multiscale (MMS) mission has completed integration of all four instrument and spacecraft decks. While there had been a fire incident at the site, the spacecraft was not impacted. The Solar Orbiter Collaboration (SOC)'s launch date has been changed by six months, and in the process of selecting a launch service provider by March 2014. Solar Probe Plus (SPP) is on track for its preliminary design review (PDR) and KDP-C in January 2014. HPD has completed the biennial Senior Review of operating missions, and the Heliophysics Roadmap is in final draft form. STP-5 is the next major mission, which is still out 5 years. HPD's plate is full, with many

assets on orbit making observations. There are currently 18 operating missions on 29 spacecraft, and six missions in development, representing a \$5.5B total investment in sum.

HPD is committed to increasing the R&A share of the budget per the recommendations of the Decadal Survey, as R&A is considered essential to the scientific productivity of HPD. MMS will be looking at the physics of magnetic reconnection in the Sun-Earth system, using a constellation of 4 satellites. The mission was affected by the shutdown, however, and the launch has been slipped by four to six weeks; it will be a challenge to stay in the launch queue because other missions scheduled to launch after MMS could be given launch priority. SOC is preparing for a 2017 launch, and will fly two US instruments. Two new Explorers were selected in 2013, to launch in 2017. ICON is a free-flying single spacecraft, and Global Scale Observations of the Limb and Disk (GOLD) is a hosted payload, which will obtain full-disk images of the ionosphere. The projected budget for HPD is flat, and the Roadmap team has been wrestling with how to carry out Decadal Survey recommendations. The final FY13 appropriations totaled \$589.7M for the division. The Roadmap considers current missions in formulation and development as the top priority. NASA's commitment is to achieve as much of the Decadal Survey as possible, focusing on the most important and highest quality research.

Current issues in HPD include impacts of a launch delay on MMS resulting from the time lost due to the government shutdown, which could amount to tens of millions of dollars in cost hits. There are some electronics parts issues open; results of tests planned for January will determine the future course of MMS. The worst case is to delay MMS to April 2015. The project is doubling up its manpower to recover schedule margins. SPP has been impacted by the sequestration, and it is currently an open question as to whether the 2018 lifecycle profile can be fit into the budget. SPP will face a possible launch delay if an adequate budget cannot be secured; a decision will be made in the Spring. HPD's R&A program has suffered significant cuts over the past few years, and the Decadal Survey has urged rebalancing the R&A fraction of the total HPD budget. The number of proposals is rising, and the fraction of proposals funded has declined to less than 15%.

HPD intends to execute commitments for current programs, implement the Decadal Survey DRIVE recommendations, grow the HP Explorer mission cadence to levels recommended by the Decadal Survey recommendation, support the HP community to demonstrate the importance of HP science and its value to society, and deliver the best possible science program within the budget and within Decadal Survey recommendations.

Dr. Maura Hagan, Chair of the Heliophysics Subcommittee (HPS), provided an update, and expressed delight at having Dr. Chenette on board in the HPD. She reported results of the September 2013 meeting of HPS, which included grading the HPD Green on government performance parameters. Speaking of the HP Roadmap, Dr. Hagan reported that HPS acknowledges Decadal Survey recommendations can't be carried out in the decadal timeframe, presenting a significant threat to carrying out HP science. Potential solutions include finding ways to engage science targets at a reduced cost, carrying out parts of the science sooner rather than later, and focusing on questions underlying mission lines vs. defining cost

caps, meaning that the community will have to incentivize innovative solutions. The HPS recommends therefore that HPD urgently study and implement ways to increase its mission frequency within its anticipated budget envelope, incorporate missions with full life cycle costs below \$100M, and adjust the scope and sequencing of planned missions in development. The Roadmap document is being finalized, with a final draft and handoff due in January 2014.

The committee briefly discussed the sobering lack of budget support for carrying out many Decadal Survey recommendations across SMD. Dr. McComas, in response to a request, promised a report on the NAC's response to the Science Committee's previous recommendations as soon as he received them. Members planned for the next meeting during the first two weeks of March.

Public comment period

No comments were noted.

Discussion

The SC drafted findings and recommendations and discussed the need to identify two SC members to sit on the joint IT Infrastructure task force.

Roundtable

Dr. McComas asked each committee member in turn to voice any remaining issues. Dr. Levy and Ms. Jurand offered no comments.

Dr. Peterson reiterated his "crank issues," i.e. cost caps on Explorers, commenting that the AP community would not want to maintain a launch rate cadence at the expense of launching bricks. He also expressed a larger-scale societal worry about the eventuality of a Carrington-level solar event, the largest solar storm on record, which could disrupt the Earth's electronic networks and put the world back into the Stone Age for 6 months. The entire electronic infrastructure is vulnerable. Prevention would require a major revamping of electronic networks and electrical grids.

Dr. Hinnners commented that the Department of Homeland Security (DHS) and other federal agencies recognize this possibility. Dr. McComas agreed to arrange briefings on this matter. Dr. Pieters added that there are other hazards such as asteroids and supervolcanoes. Within NASA's purview of risk vs. impact, it would be nice to see how these events stack up relative to each other in terms of risk/incidence. Dr. Luhmann recommended a brainstorming session, including John Grunsfeld, on the position of science in the country and on budgetary priorities.

Dr. Hinnners commented that it was good to have the committee discussing real problems and not just listening to presentations.

Dr. McComas adjourned the meeting.

Appendix A
Attendees

NAC Science Committee members

David J. McComas, Southwest Research Institute, *Chair*
Carlé Pieters, Brown University, *Vice Chair*
Maura Hagan, NCAR, Chair, Heliophysics Subcommittee (via telecon)
Noel Hinners, retired (via telecon)
Mark Robinson, Arizona State University (via telecon)
Janet Luhmann, UC Berkeley, Chair, Planetary Science Subcommittee
Eugene Levy, Rice University, Chair, Planetary Protection Subcommittee
Bradley Peterson, Ohio State University, Chair, Astrophysics Subcommittee
Steve Running, University of Montana
Deirdre L. Jurand, NASA Headquarters, *Executive Secretary*

NASA Attendees

Gale Allen, NASA Headquarters
Marc Allen, NASA Headquarters
Dave Chenette, NASA Headquarters
Jonathan Cirtain, NASA MSFC
Catharine Conley, NASA Headquarters
Ann Delo, NASA Headquarters
Vicki Elsbernd, NASA Headquarters
T. Jens Feeley, NASA Headquarters
Michael Freilich, NASA Headquarters
James Green, NASA Headquarters
John Grunsfeld, NASA Headquarters
Hashima Hasan, NASA Headquarters
Paul Hertz, NASA Headquarters
Mona Kessel, NASA Headquarters
Bob Leamon, NASA Headquarters
Jeff Newmark, NASA Headquarters
Arik Posner, NASA Headquarters
Andrea Razzaghi, NASA Headquarters
Christy Rivera, NASA Headquarters
Eric Smith, NASA Headquarters
Rita Sambruna, NASA Headquarters
Stephanie Stockman, NASA Headquarters
Ellen Stofan, NASA Headquarters
ElSayed Talaay, NASA Headquarters
Ray Taylor, NASA Headquarters
Rita Tsaoussi, NASA Headquarters
Craig Tupper, NASA Headquarters
Nicholas White, NASA GSFC
Dan Woods, NASA Headquarters

Non-NASA Attendees

NAC Science Committee, December 3-4, 2013

Francesco Bordi, Aerospace
Dom Conte, Millennium Space Systems
Charles Fletcher, MSL LL Study
Dan Leone, Space News
James Lochner, USRA
Jon Malay, Lockheed Martin
Michael Moloney, NRC-SSB
Mark Saunders, MSL LL Study Team
Ana Wilson, Zantech IT
Joan Zimmermann, Zantech IT

Webex Participants

Louis Barbier
Linda Billings
Stephen Clark
James Dean
Christopher Flaherty
Lewis Groswald
Marchelle Holle
Bethany Johnson
V. Kane
Lou Kaluziński
Brad Kielor
David Lang
Bill Mackey
Barry Miller
David Millman
Joel Parriot
Diane Pugel
Mark Robinson
Gerald Smith
Marcia Smith
Shannon Valley
Ann Zukolsky

Appendix B
NAC Science Committee Membership

Dr. David J. McComas
Southwest Research Institute (Chair)

Dr. Carlé Pieters
Brown University (Vice Chair)

Dr. Douglas Duncan
University of Colorado

Dr. Maura Hagan
National Center for Atmospheric Research

Dr. Noel W. Hinners
Lockheed-Martin (retired)

Dr. Charles F. Kennel
University of California, San Diego (*ex officio member*)

Dr. Eugene H. Levy
Rice University

Dr. Janet Luhmann
University of California, Berkeley

Dr. Bradley Peterson
Ohio State University

Dr. Mark S. Robinson
Arizona State University

Dr. Steve Running
University of Montana

Dr. Meg Urry
Yale University

Deirdre L. Jurand, Esq.
Executive Secretary

Appendix C
Presentations

1. Science Mission Directorate Science Plan Status; *Dan Woods*
2. Science Mission Directorate Budget Status; *Craig Tupper*
3. Earth Science Division/Earth Science Subcommittee Update; *Michael Freilich*
4. Planetary Protection Office/Planetary Protection Subcommittee; *Catharine Conley, Eugene Levy*
5. Astrophysics Division Update/Astrophysics Subcommittee; *Paul Hertz, Bradley Peterson*
6. Astrophysics Roadmap Status; *Bradley Peterson*
7. JWST Status; *Eric Smith*
8. Planetary Science Division Update/Planetary Science Subcommittee; *James Green, Janet Luhmann*
9. Mars Science Laboratory Lessons Learned; *Mark Saunders*
10. ASRG Case Study/Technology Development and Maintenance; *David Schurr*
11. Heliophysics Division/Heliophysics Subcommittee; *Dave Chenette, Maura Hagan*

Appendix D
NAC Science Committee
December 3-4, 2013

Agenda
(all times EASTERN)

Tuesday, December 3 (9H40, unless noted)

8:30-8:35am	Opening Remarks – D. Jurand/ D. McComas
8:35-9:05am	SMD Science Plan Status – D. Woods
9:05am-9:35am	Budget Status – C. Tupper
9:35-9:45am	Break
9:45-10:45am	Earth Science / ESS – M. Freilich
10:45-11:15am	Planetary Protection/PPS – G. Levy / C. Conley
11:15am-12:00pm	Discussion
12:00-1:00 pm	Lunch on Own
1:00-2:00pm	Astrophysics / APS – B. Peterson / P. Hertz

NAC Science Committee

December 3-4, 2013

Agenda

(all times EASTERN)

Wednesday, December 4 (MIC-3/Room 3H42, unless noted)

8:30-8:35am Opening Remarks/Announcements – D. Jurand / D. McComas

8:35-9:35am Planetary Science / PSS – J. Green / J. Luhmann

9:35-9:45am Break

9:45-10:45am Results of the MSL Lessons Learned Study – M. Saunders

10:45-11:45am ASRG Case Study/Tech development maintenance – D. Schurr

11:45am-12:15pm Discussion

12:15-1:15pm Working Lunch

