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MEETING REPORT



David J. McComas, Chair



Deirdre L. Jurand, Executive Secretary

Table of Contents

Welcome and Introduction	3
NASA Strategic Plan Development/SMD Science Plan	3
Discussion of Strategic and Science Plans	5
SMD Budget Status	7
NEOs and Planetary Defense	8
Planetary Science Division and Subcommittee Updates	10
Astrophysics Division and Subcommittee Updates	13
Discussion with the NASA Administrator	15
James Webb Space Telescope	16
Heliophysics Division and Subcommittee Updates	17
Earth Science Division and Subcommittee Updates	19
Planetary Protection Office and Subcommittee Updates	20
Public comment period	21
Discussion of Findings and Recommendations	21

Appendix A- Attendees

Appendix B- Membership roster

Appendix C- Presentations

Appendix D- Agenda

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July 29, 2013

Welcome and Introduction

The NASA Advisory Council (NAC) Science Committee (SC) Executive Secretary, Dr. T. Jens Feeley, opened the meeting and made administrative announcements.

Dr. David J. McComas, incoming Chair for the SC, opened the meeting and welcomed members. Dr. Mark Robinson was welcomed as the committee's newest member. Dr. McComas noted that the SC would be preparing in short order for an impending NAC meeting on Wednesday, 31 July, and that Mr. Charles Gay would be sitting in for Science Mission Directorate (SMD) Associate Administrator (AA) Dr. John Grunsfeld who was on leave. Dr. McComas offered his personal perspective on committee workings, viewing the SC's function as a unification of disciplines that might ultimately speak with one voice in support of all of Earth and space science.

Strategic Plan/SMD Science Plan Status

Ms. Julie Pollitt briefed the SC on the new format of NASA's Agency-wide 2014 Strategic Plan. Through the Office of the Chief Financial Officer, Ms. Pollitt has been leading this effort for 9 months, in close coordination with the Office of Strategy Formulation. She made the distinction between strategic planning and Strategic Plan development, the former of which is an ongoing activity. By contrast, the Strategic Plan itself is re-formulated every four years, documenting strategic planning that has been accomplished to date. Stakeholder engagement is a facet of this activity, including key stakeholders such as Congress, the Office of Management and Budget (OMB), the National Academy of Science (NAS) and the public.

The NASA Strategic Plan communicates priorities and direction, which must be stable and feasible for the long-term, to stakeholders inside and outside of NASA. The plan must communicate both the ideal and the reality of the changing federal government, as the Agency, particularly of late, does not always obtain its planned funding level. The 2010 Government Performance and Results Act Modernization Act (GPRAMA) is another challenge, as GPRAMA also requires that a Performance Plan, Performance Report, and quarterly performance reviews be incorporated into strategic planning, making it more complicated than in the past.

GPRAMA has changed planning and reporting requirements at the Agency level, through the government-wide effort to clarify roles and responsibilities, accompanied by a great number of new cycles and reviews. NASA must account for all these new components in the new Strategic Plan. The Aeronautics and Human Space Flight communities are also undergoing re-planning efforts. Requirements for the Strategic Plan, scheduled for release in February 2014, will affect how its language is formulated, as the format now includes website constraints. Annually, NASA must measure progress against its strategic objectives and report to OMB, which further influences budget decisions and constitutes a feedback loop for changes in strategy over time.

What is new since 2011 is that there is much less flexibility in developing content for the Strategic Plan, and there are new requirements; it is not so free-form anymore. This is the first Strategic Plan that requires four different versions (Hill version, OMB version, etc.) and many more reviews, resulting in shortened timelines. There are new priority goals that are required to be articulated every other year as well as a Human Capital Strategy Plan required by OMB.

The committee discussed ramifications of the new GPRAMA requirements. Ms. Pollitt explained in response to questions that the number of staff needed to develop the Strategic Plan is comparable to past years. However, in terms of priority goals and the maintenance of content at www.performance.gov, there has been monstrous growth on the performance side; this requires much more effort to review at the goal and objective level. The cross-cutting top level goals and objectives will require the most effort. In general, the GPRAMA effort requires about 5 times more work. Therefore, NASA has been reallocating hours to bureaucracy, essentially, from the planning side. However, contractor staff have been hired to assist in the process. The strategic planners themselves are doing about twice the work. There is no new money to support this effort. While NASA is formally tracking hours for the new effort, Ms. Pollitt expressed doubt that OMB will ask for the information. However, the number of hours is being tracked for NASA planning purposes.

Asked how the science portion of the Strategic Plan is being dealt with, Ms. Pollitt reported that it would be placed within the strategic objective portion of the plan, in addition to its three additional categories of strategic goals, strategic objectives, performance goals, and annual performance indicators. There are three new strategic goals; and four of the 15 new strategic objectives belong to SMD (one for each of our science themes). The requirements have been hung at the strategic objective level, which creates a new emphasis on the importance of the strategic/science objectives; so far, the science objectives appear to pass muster with OMB. NASA had originally planned to go to NAC to get a review of the full set of strategic goals and objectives in April. Dr. McComas requested that the SC be sent the latest version of the draft.

Dr. Carle Pieters commented that the emphasis seemed to be very OMB-heavy; and since Congress funds NASA, asked what the Congressional input will be like. Ms. Pollitt noted that this is the first instance of the GPRAMA process being carried out. There has been ongoing work with Congress, with input usually given once per year on the way to appropriations; this year marks the first time NASA has sent a Strategic Plan draft to Congress for formal comment. Congress is interested in seeing that the plan reflects its priorities, and in understanding if NASA is still on the right path. For the purposes of the science disciplines, there is clear mapping between the SMD Science Plan and the NASA Strategic Plan. Asked what is behind the GPRAMA effort, Ms. Pollitt believed that the act is scooping up the different pieces of past performance measurement efforts, to achieve transparency through a more comprehensive set of requirements in a single location. The attempt to adopt more commonality across the federal government has been somewhat effective and successful; everyone must have strategic goals, objectives and performance measurements. Now there is a single structure upon which to do comparative analysis.

Mr. Dan Woods briefed the SC on the SMD Science Plan with an update on its development since the Committee's last meeting in April 2013. Since that time the Science Plan has undergone an internal SMD

review. Once the SC has provided feedback, the Space Studies Board will review the document through August/September and will report out its comments in November. The Science Plan is scheduled for release shortly after the President's budget request is released in February 2014. After discussing strategic objectives for Earth Science, Astrophysics, Planetary Science and Heliophysics, the committee expressed concern with 1) the Heliophysics objective's placement under Goal 2 instead of Goal 1 within the NASA Strategic Plan, and 2) with the narrowness of Heliophysics' top level goal and misapplications of the terms "heliosphere" and "solar system" in the Science Plan's descriptions. There was extensive discussion of the placement of the Heliophysics science objective in the "Earth" category instead of the "Science" category – a fact that Ms. Pollitt had shared in answering a question – and a call for the Heliophysics bullet to include a specific reference to covering all of the space physics from the Sun out to the local interstellar medium. Mr. Woods agreed to address language issues in response to SC concerns. He added that additional challenges for the 2014 Science Plan are the inclusion of three new elements: meeting scientific and societal needs (space weather and climate change); national science and technology workforce development; and unstable budget environment. The next draft will be submitted to the National Research Council (NRC) for review in early August.

Discussion

The committee discussed further input into the NASA Strategic Plan and the SMD Science Plan. Dr. Meg Urry reiterated a prior committee concern about the consolidation of Education and Public Outreach (EPO) funds from numerous federal agencies and departments (including NASA) into 3 and commented that this was a major step backward for education. Ms. Cynthia Lodge commented that internally, NASA is maintaining a backup plan in case the planned consolidation is rejected by Congress; the Agency's Education Coordination Council (ECC) will still work to prioritize how the funds will be distributed. No position losses are anticipated in October, as the assumption is that the Continuing Resolution (CR) will remain in effect. To that end, NASA centers have been instructed to continue funding these activities under a CR. Dr. McComas noted that the previously issued, strongly worded EPO recommendations from the SC were non-concurred by the NASA Administrator.

Dr. Eugene Levy asked to what extent is the Strategic Plan a synthetic process. Ms. Pollitt responded that when considering long life cycles, ongoing planning must deal with changes in the environment and the budget. In short-term implementation of long-term goals, program/project planning goes on constantly. She agreed that the Strategic Plan is essentially descriptive, but it brings out common touch points between mission areas; the plan is a good forcing function to bring people together. Mr. Woods noted that the reporting process includes metrics that show NASA performance, which allows the Agency to identify measures of success. Planning has also helped NASA develop more integration within the Agency, identifying a link between Astrophysics and Planetary Science, for instance, in exoplanet research. Dr. Janet Luhmann commented on the larger issue of where science now sits in both NASA and the national priority. There is a move to commercialize space science and some elements of Earth Science missions. With respect to pure exploration, is NASA doing a good job justifying the investment? Education had been the most obvious argument, and now it is broken. Ms. Pollitt felt that one of the key messages in the Strategic Plan concerns the benefits of NASA back to the public; the plan should try to explain the relevance of all the things that NASA does. The benefit back to the taxpayer is captured in the Strategic Plan language, which is why the Agency made conscious decisions about science placement in

the document. As an example, Heliophysics gets discussed in terms of its benefits back to Earth (space weather). This is a tangible understandable benefit to the layperson. Dr. Luhmann felt that NASA should think harder about communicating the fundamental and inspirational value of science.

Dr. McComas remarked that it sounds like the four science themes in SMD get accounted for in two different ways. Ms. Pollitt responded that many things at NASA cross over, but in the GPRAMA process, the Agency can bookkeep strategic objectives in only one location. Dr. Maura Hagan commented that there are unintentional consequences of highlighting Heliophysics benefits back to Earth at the expense of the importance of its fundamental science goals. Ms. Pollitt felt these goals were represented in terms of the full breadth of science significance. The true motivation for strategic goal placement was how to best protect support for SMD. Mr. Woods mentioned that SMD had written a white paper on the subject of the Heliophysics goal placement. Dr. McComas requested a copy of the white paper; he further noted that portions of the Space Act and selected parts of previous Congressional authorizations seemed cherry-picked in the Science Plan language. Mr. Woods explained this as an attempt to identify active authorizations (i.e., laws on the books today) that guide NASA strategy. Mr. Woods agreed to ensure that the context of the language would be more explicitly stated.

The committee returned to a discussion of the EPO issue, reviewing the statement of non-concurrence by Administrator Bolden. The words seem to support the SC position, yet NASA non-concurred. Cynthia Lodge commented that any funds that have left the agency will be used in STEM/Outreach and that every agency in the federal government has done this. Each agency can communicate its preference in how education funding is directed, but it appears that the ultimate decision resides with the Administration. No one yet knows how the final prioritization will be dispositioned across the federal government. Dr. Luhmann remarked that all the groups at the bottom of the food chain are in a state of limbo and asked what would replace the Education efforts associated with each NASA mission. Ms. Lodge responded that the Goddard Space Flight Center (GSFC) would be most affected, and that NASA HQ is steadily communicating out to the affected communities, advising prudence, especially as 2014 comes nearer. Ms. Pollitt commented that internally, the NASA civil service workforce most directly involved is covered and will remain covered. In the grants arena, because much of that work seems to lag, there should be some bridge funds.

Dr. McComas suggested that the SC accept that the Administrator is doing everything in his power to support EPO and instead develop a finding that would be useful to NASA. Dr. Luhmann recommended that the Strategic Plan be used to make the argument that scientists should be more directly engaged in STEM. Ms. Pollitt responded this is exactly what the Strategic Plan's strategic objective states, and requested further input on how the science community could help NASA communicate STEM benefits to the public in an understandable way. Dr. Robinson expressed a concern that by removing aspects of EPO, NASA efforts will be diluted. The Government Accountability Office (GAO) had criticized EPO as an area of duplication across several agencies, which is why they recommended this government-wide consolidation. Dr. Urry suggested that NASA be regarded as a testbed in which it is clear to see that in the years before NASA integrated education with science missions, the EPO effort did not penetrate textbooks, for example. This changed about 20 years ago when EPO was integrated into NASA programs: that's when NASA efforts in support of EPO activities really started to have an impact. Dr. McComas tasked Drs. Urry, Peterson and Pieters to craft a finding/recommendation on EPO.

Dr. Noel Hinners commented that the SC is still faced with the fact that much of the problem is external to NASA and is unlikely to be fixed working up through NASA. In that light, committee members have a responsibility to impact the environment through their home institutions and Congress. Ms. Lodge cautioned against lobbying, which could impact NASA funding adversely. Dr. Urry commented that the strategic planning effort seemed to be “d  j   vu all over again.” The move to uniformity is understandable, but it still looks like a lot of effort for fuzzy or many possible purposes. Planning used to come up from the grass roots to funnel into a global plan. Ms. Pollitt felt that taking the guesswork out of the structure helps NASA to understand what OMB and Congress want, but acknowledged that it is tough to adopt a new set of requirements. Mr. Woods welcomed responses for improvements to the NASA Strategic Plan and the SMD Science Plan, and offered some leeway on deadlines.

SMD Science Budget Status

Mr. Craig Tupper briefed the Committee on the status of the NASA Science Budget, delivering the good news that recently NASA has been launching several missions on schedule and budget. Some missions in development are actually coming in under budget, such as the Mars aeronomy mission (MAVEN), Global Precipitation Measurement (GPM), Juno, and the lunar mission Gravity Recovery and Interior Laboratory (GRAIL). Compared to the conditions of the past, where some missions ran over by 25-30%, NASA is quite pleased. Factors influencing this change include better budgeting from the outset, including the establishment of a 70 percent joint confidence level (JCL) requirement, better management, as well as the implementation of more rigor in phase A, through launch and beyond.

Mr. Tupper reviewed SMD’s actual appropriations since 2001, and noted that the top-line funding is expected to remain in decline from 2013 on. Science remains at its historical average as a percentage of the Agency budget, between 25-30%. Within the FY13 Budget and Operating Plan, total Science as appropriated stands at \$4781.6M, but the Operating Plan is still not final, subject to impending decisions from the Hill. There have been efforts to increase funds for the Planetary Science Division (PSD), but it is a zero sum game. There is potential impact on the launch date for the James Webb Space Telescope, but Mr. Tupper noted there is broad Congressional support for JWST. In the meantime, NASA is trying to minimally disrupt missions that are currently in phase C/D. Dr. McComas asked about the implications of an unapproved Operating Plan. Mr. Tupper felt there would be no effects on the work of projects over the next two months, but that NASA would be unable to make any new starts. Any available funding will be applied to existing projects.

To demonstrate the impact of the FY14 sequestration, Mr. Tupper presented numbers from the Senate and House Appropriations Bills for comparison. NASA will continue to operate on the assumption that sequestration will kick in; therefore next year the Agency would be expected to be funded at \$16.2B, as opposed to the \$17.7B request. Science will be reduced from \$4.7B to \$4.6B in this scenario, with a difference of about \$30M depending upon the passage of the House or Senate sequestration versions, with varying breakdowns for JWST and the 4 science divisions. The key message is that either version of the appropriations bill will present NASA with funding challenges. If sequestration continues, there will be a considerable decline in the Science budget to roughly \$4B in buying power (through erosion by inflation) by 2018. Termination of missions in early development could be necessary, or possibly operating

missions that have not been rated highly by the Senior Review. More likely, there will be reductions in competed research commensurate with the overall budget. Effectively, cuts of \$350-375M per year in SMD are possible. Dr. Paul Hertz, Director of the Astrophysics Division (APD) interjected that NASA does not require additional funds at this point to implement its present programs that are covered in the five-year budget planning cycle.

NEOs and Planetary Defense

Mr. Lindley Johnson briefed the committee on the status of NASA's Near Earth Object (NEO) program, providing background on Earth's known impact craters. The youngest confirmed crater on Earth is the Wabar crater in Saudi Arabia (140 years old, 110 miles in size), an event referred to as "the day the sands caught fire." The Barringer crater, which is much smaller by comparison, is estimated to have been able to cause a 25 percent casualty rate in Winslow, Arizona, had the event occurred in the modern era. Impact frequencies of NEOs are estimated at about once every 50 years for an object greater than 30m in size. The Tunguska event, the size of which is purported to occur every few centuries, impacted an area of 800 square miles, equivalent to the area of New York City. Extinction class events (a 10 km object) are estimated to occur every 100 million years. Notably, the Chelyabinsk event (17-20 m object, releasing 400-450 kiloton TNT of energy) has raised consciousness about the threat of NEOs. Since the Chelyabinsk incident in February 2013, there have been four Congressional hearings concerning NASA's role in NEO detection.

The US government's policy and approach to NEOs are outlined in a 2010 letter to Congress from the White House's Office of Science and Technology Policy (OSTP), directing NASA to pursue capabilities to find and characterize NEOs, and determine which objects are threats. Consequently, NASA has expanded the NEO program from a \$4-5M/year program to \$20M/year, and the President's FY14 budget request includes \$40.5M. NASA has the responsibility to identify and detect NEOs and, in the unlikely event of a pending collision with an NEO, to inform other federal agencies, after appropriate protocols have been followed. The Federal Emergency Management Agency (FEMA) would take the lead in notifying Federal, state and local authorities, while the US Department of State would facilitate international notifications.

NASA-funded NEO detection programs have discovered an estimated 98% of all new NEOs discovered since 1998. This effort began with a NASA commitment to find at least 90% of one-kilometer or larger sized NEOs, having met this goal in 2010. The NASA Authorization Act of 2005 set an even more ambitious goal for NASA's NEO detection program to detect 90% of NEOs greater than 140 meter in size by 2020.

The NASA NEO Search Program uses a number of ground-based observation facilities, located at the Massachusetts Institute of Technology's Lincoln Laboratories (LINEAR), Arizona and Australia's Catalina Sky Survey telescopes, and the University of Hawaii observatory at Haleakala, HI (Pan-STARRS). The NEO Program Office is located at the Jet Propulsion Laboratory (JPL) for program coordination and precision orbit determination. There are currently 10,063 known near-Earth asteroids. Asked whether NEO employed any citizen science projects, Mr. Johnson responded that we are now entering an era where NEO detection is beyond the capabilities of most amateur astronomers, but NASA

does maintain an active EPO program that uses database images to teach students and non-professional astronomers how to detect asteroids; some asteroids have in fact been detected in this way.

A key role in the international NEO discovery and characterization process is played by the Minor Planet Center (MPC), which receives and correlates data from sources all over the world. The rough orbit of the object and impact potential are determined and corroborated by planetary radar observations. JPL then publishes the probability of impact. As soon as MPC receives information about a possible new NEO, there is an immediate notification sent to ground-based facilities to see if they can observe, track and help characterize the object. The physical characteristics of NEOs are determined by IR data, light curve data, and long-arc high precision astrometry, and the mass is estimated using inferred or assumed density. Composition can only be roughly assessed via analogy to spectral data on meteorites and terrestrial rocks. Radar observations of NEOs are made at Arecibo's 305-m radio dish, and NASA's Goldstone 70-m radar. Radar can provide information about shape, spin rate, surface density and roughness. Radar currently obtains information about 70-80 NEOs per year. The NASA Infrared Telescope Facility (a dedicated planetary science observatory) and the Spitzer IR Space Telescope, the latter of which is in a warm extended mission phase, also provide data.

Mitigation research is ongoing, including Kinetic Impactor demonstration mission studies, NASA Innovative Advanced Concepts Program, and NEO Observations Program mitigation effects grants. There is also a NASA concept study underway to look at a potential addition to the OSIRIS-REx mission, called the Impactor for Surface and Interior Science (ISIS). Interagency efforts include impact effects studies at the Department of Energy (DOE), US Air Force emergency response exercises, FEMA Headquarters tabletop exercises, and the Defense Advanced Research Projects Agency (DARPA). International efforts are carried out through the United Nations Committee on Peaceful Uses of Outer Space (UN-COPUOS).

Future capabilities for planetary defense will require space-based and tracking capabilities. Lagrange point 2 (L2) is thought to be a potential location for IR detection to look at "sweet spots" at L4 and L5; a Venus-like orbit is also under consideration. There is currently a Space Act Agreement with the B612 Foundation to build the first privately developed and operated IR spacecraft for viewing NEOs; NASA is helping to support technical development for this spacecraft. The proposed Asteroid Redirect Mission (ARM) included funds for an enhanced NEO Observation Program, amounting to \$40M in the President's 2014 budget request. Other enhancements under the plus-up include time on DARPA's Space Surveillance Telescope. The Asteroid Initiative Request has yielded 90 responses on NEO observations, 30 of which are considered viable.

In summary, NEO observation is a rapidly expanding mission for planetary sciences. Reactivating the WISE spacecraft for NEO observation, referred to as the NEO-WISE mission, would mean bringing it out of hibernation; this is considered to be one of the low-cost ways to find hazardous objects of 100m in size. Dr. Pieters suggested that NASA examine NEO impact probabilities in terms of relative risks compared to supervolcano or Carrington-scale solar storm events; it would be good to understand where the NEO risks stands. Mr. Johnson cited published papers on relative hazards by Morrison and Clark (1995), and tabular data from a recent NRC report. High-level assessments have concluded that the risk of dying from an asteroid impact about equivalent to dying in an aircraft accident (this figure is averaged

over geologic time and includes the massive Cretaceous-Tertiary extinction event). Dr. Levy commented that the real issue is how to define the threshold for action, which is not a simple decision.

In response to questions about costs, Mr. Johnson commented that the \$40M targeted for NEO discovery will not support a space-based capability. The Agency and NASA must decide how much to expend on the effort. Significant mitigation efforts would likely require a reallocation of funds. Reactivation of the WISE spacecraft could however be accommodated within the \$40M figure. NASA is also considering the use of balloon assets for NEO detection.

Discussion

Mr. Gay made brief comments, extending Dr. Grunsfeld's regrets for his absence. The committee further discussed language specific to the Strategic and Science Plans. Mr. Gay addressed the ongoing impacts of the sequestration, and stressed that the principles normally applied to SMD will continue to remain in effect. Everyone understands the cost impacts of slipping missions; R&A will remain at roughly the same percentage of overall budget, and extended missions will be scrutinized at the Senior Reviews.

July 30, 2013

Opening remarks

Dr. McComas opened the day's proceedings, describing a discussion with the Information Technology Infrastructure Committee (ITIC) Chair Larry Smarr, and noting that there has been additional pressure from the NASA Inspector General report that might push NASA towards a more centralized approach to IT infrastructure management. Dr. McComas believes it would be advantageous to work with the ITIC in formulating a joint finding to submit to the NAC on the subject of IT.

Planetary Science Division/Planetary Science Subcommittee

Planetary Science Division (PSD) Director Dr. James Green briefed the SC on the status of PSD. There have been two launches this year. The most recent is the Lunar Atmosphere and Dust Environment Explorer (LADEE) on 6 September from the Wallops Flight Facility. LADEE is a lunar orbiter that will measure lofted dust in the lunar exosphere. The mission also carries a laser communications device, a technology demonstration designed to transmit data at 622 Mbits/second, five times the rate compared to state-of-the-art from lunar distances. LADEE is the first lunar mission to be flown out of the Wallops facility and will help provide a major step in laser communications for planetary science.

There have been a number of planetary mission events this year to raise public awareness, including a Mars as Art exhibition at Dulles Airport in Virginia, Spacefest in NYC, and National Air and Space Museum (NASM) Mars day. Wave-at-Saturn and Wave-at-Mercury media events, through the Cassini and MESSENGER missions, were quite popular and received wide coverage. The one-year anniversary of Curiosity at Mars is approaching and will be recognized with the placement of a rover model at the Hart Building in Washington, DC. The Juno spacecraft will fly by Earth in its last gravity-assist maneuver before arriving at Jupiter in 2016. VESPER, a mission to Venus, will observe the deuterium/hydrogen ratio on the planet.

MAVEN, launching in November 2013, will look at the structure and composition of the Mars

atmosphere and its interaction with solar wind. Curiosity has taken measurements of argon isotopes that indicate much of Mars' atmosphere has been stripped away; MAVEN will look more closely at this phenomenon. The spacecraft has gone through thermal vacuum testing and is ready to go to Cape Canaveral. OSIRIS-REx (launch date: September 2016) is approaching Key Decision Point C (KDP-C). OSIRIS-REx will encounter the asteroid 199RQ 36, now named Bennu, a 500-meter carbonaceous chondrite. The spacecraft will loiter at the asteroid for 500 days and in addition to physicochemical analyses, will measure the Yarkofsky effect.

InSight, a mission approaching KDP-C in FY14, will place a seismographic device, heat flow instruments and cameras at the Mars equatorial region. The New Horizons spacecraft has had a full dress rehearsal, in anticipation of its flight through what is now known to be a more complicated system, given the recent discovery of two additional moons at Pluto. The dress rehearsal executed commands over a nine-day period, and performed flawlessly. New Horizons will arrive at Pluto in July 2015. The two new moons have been named Styx and Kerberos. PSD has also received the Science Definition Team (SDT) report for the Mars 2020 rover, which will be looking for organics at Mars, enabling technologies, and creating a returnable cache of samples. The mission may include work with the Human Exploration and Operations Mission Directorate (HEOMD) to demonstrate in-situ resource utilization (ISRU). An Announcement of Opportunity (AO) for the 2020 instruments will be released in early fall of this year.

Comet ISON, discovered in September 2012, will be making its closest approach to Mars in October 2013 and can be observed by Curiosity and Opportunity. Its closest approach to Earth occurs on 26 December if it survives its solar encounter. ISON is an Oort cloud comet and will be observed by Swift, Spitzer, a planetary balloon flight and a sounding rocket flight, and various other spacecraft including the Mars Reconnaissance Orbiter and the Solar Dynamic Orbiter. Spitzer observations indicate it is about 2 km in size. ISON has not yet formed a tail; estimates are that it is emitting 1M kg of CO₂ per day. In other planetary science campaigns, space-based observations of the Jovian system are being planned via the Japan Aerospace Exploration Agency's (JAXA) SPRINT-A/EXCEED telescope, which will view the far-ultraviolet spectra of the Io torus and Jovian aurora. Gemini North and NASA IRTF assets will view the moons as well, and will look at outgassing at Io.

The proposed Asteroid Re-direct Mission (ARM) to capture and redirect a 7-10 meter asteroid to near-Earth space by 2021 is currently under review by the Small Bodies Advisory Group (SBAG) of the Planetary Science Subcommittee (PSS). This is a technology demonstration mission, potentially valuable for science. PSD's role in ARM will be to identify a target asteroid through ground- and space-based observations, and to enhance survey capability. ARM is managed at the Agency level at present. One mission concept has been fleshed out, and will probably be carried out through the Space Technology Mission Directorate (STMD) or HEOMD.

Dr. Green provided a quick status of the NEO program, which will be enhanced by funding from ARM to help find 90% of the 140-meter class NEOs within 15 years. Space-based assets would probably best serve this effort; therefore, NASA has been working with the private foundation B612 through the Space Act. B612 is developing an IR telescope in the 2016 timeframe, which will launch to a Venus-like orbit. If the company cannot provide the significant funding necessary, NASA will continue to improve its

ground-based capabilities; this is still in the planning stage. There is no move afoot to duplicate what B612 is doing. Details of their progress were unavailable at the time of the meeting.

The Astrobiology Institute is undergoing cycle 7 of its cooperative agreement (CA). A draft agreement has been issued and cycle 7 teams will replace the cycle 5 teams that have completed their five-year CAs. With regard to NASA's radioisotopic power systems (RPS) and the status of Pu-238 production, NASA continues to work with DOE to size the problem and leverage existing facilities. Plutonium has not been created domestically since 1988; new Pu supplies are being designed to be mixed with the old to provide sufficient energy density for future missions. Within the FY14 funding realignment for RPS, NASA will be funding infrastructure at DOE to execute RPS flight unit development, production, and safety management. Dr. Green has created a zero base review committee to oversee this venture. Findings and recommendations are due by October and will be presented to OSTP and Congress. PSD will report results to the NAC at its next meeting. Asked about Advanced Stirling Radioisotope Generators (ASRGs), Dr. Green noted that PSD is developing an ASRG on the concept of a Stirling engine that will use a quarter of the Pu compared to previous designs. Dr. McComas raised the continuing concern with NASA "owning" the risks of Pu-238 production. Dr. Green reported that the zero base committee will consider the risks to NASA and provide recommendations on the governance of the project; it is not NASA's intent to take on the risk. Safety is to be clearly in DOE control; NASA will be responsible for the funding, and does not intend to shoulder the responsibility for safety within DOE. Dr. Urry asked about the Senate Appropriations bill that seeks to reinstate two Discovery missions, and how their potential reinstatement would affect PSD planning and budgets. Dr. Green responded that PSD would re-plan to accommodate the missions; trades would have to occur, such as pushing out the next Discovery selection. Dr. Robinson mentioned that the landing of China's Chang'e III on the moon during the prime mission of LADEE will fundamentally change the experiment and asked if NASA were able to communicate with the Chinese space agency in order to maximize potential science. Dr. Green noted that NASA is forbidden to engage in bilateral discussions with China.

PSS status

Dr. Janet Luhmann, Chair of the Planetary Science Subcommittee (PSS), presented a status of the subcommittee's latest activities. The PSS held a Webex meeting on 19 July, hearing briefings on PSD status, the Mars 2020 rover mission, and updates on the Astrobiology Roadmap and R&A. Changes of note include community anticipation of the budget, potential game changers associated with the 2020 mission, new proposals to the Solar System Exploration Virtual Research Institute which are currently under evaluation, an AO for the new Astrobiology Institute cycle, an SBAG evaluation of the ARM, and continuing assessment of the PSD R&A programs.

The PSS considered the Mars 2020 SDT report to be an impressive document, having defined 4 key objectives for a rover based on MSL design, geologic context, in situ Astrobiology experiments in specific detail beyond the abilities of MSL, and ISRU-related demonstrations in anticipation of humans on Mars. Proposed instrumentation includes context imaging, context mineralogy, fine-scale elemental chemistry, and organic detection. The mission development may also include efforts to decrease the landing ellipse, develop zoom capability for imaging, and design a payload capable of recognizing biosignatures. The Mars Exploration Program Assessment Group (MEPAG) has met with Jack Mustard,

chair of the SDT, and expressed broad acceptance of the report.

The Astrobiology Roadmap exercise continues. The Roadmap is revamped on a 5-year cycle, considering how NASA studies map from prebiotic chemistry to the formation of habitable worlds. The current roadmapping revision is using electronic communications to broaden community participation through webinars and chats. Thus far webinars have been held on the subject of prebiotic evolution and advanced life evolution. Twenty-one concept documents have been written as a result, and will be posted at astrobiologyfuture.org.

PSS issues are focused on the budget, R&A programs, the planetary science workforce, restoration of mission opportunities such as Discovery and New Frontiers, the uncertain fate of the proposed Europa clipper mission, and procedures for private enterprise involvement with NASA missions. Dr. Green commented that \$15M has been provided to the community for instrument concept definitions for Europa.

Dr. Luhmann presented recent science highlights, including Cassini's breathtaking images of a polar vortex or hurricane at Saturn and views of the planet's rings, which regularly catch meteors, with impacts clearly seen as angled streaks on the rings. A recent A ring impactor is estimated to be the size of the 2013 Chelyabinsk object. LRO/LAMP observations of the GRAIL impact on the Moon were successfully modeled, enabling a computer model of the impact cloud showing multiple spherical shells coming out of the impact. Evidence has been found on Venus of volcanism, mantle plumes, and volatiles. Data suggests that there is modern water on Venus, supplied by volcanic activity, along with outgassing of SO₂. Comet Garradd, observed by the Deep Impact flyby, showed an unusual composition, the highest CO/H₂O ratio ever measured (60%).

The last PSS recommendations that were moved up to the NAC were the subcommittee's continued concerns about the future of planetary science with respect to budget projections, R&A stress, and EPO activity.

Astrophysics Division Update/APS

Dr. Paul Hertz, Director of the Astrophysics Division (APD), provided an update, beginning with science highlights. The Hubble Space Telescope (HST) recently provided images of a transit of the closest known hot Jupiter-sized planet, found to be bright blue in color, about the same blueness of Earth. Its blue atmosphere is attributed to windy dispersion of shards of molten silicate. Swift measured an "anti-glitch" in the magnetar 1E2259+586, a star-quake, which decreased the moment of inertia, causing a decrease in spin. Spin-down had never been seen before, and may be the result of a CME expelling stellar material.

APD has been doing a good job within its constraints. An SDT evaluated the use of National Reconnaissance Organization (NRO) optical assets to meet the science goals of WFIRST with a mission concept now known as Astrophysics Focused Telescope Assets (AFTA). The mission would provide better quality imaging than that originally envisioned for WFIRST, and can also add a coronagraph. NASA Headquarters has given APD direction to continue pre-formulation activities to preserve the option of choosing this as a mission to follow JWST, using the NRO assets. This is essentially the third Design Reference Mission (DRM) for WFIRST. APD continues to study AFTA because it offers better science

for approximately the same cost, while they continue to study alternative missions. APD will downselect to two coronagraph technologies by December 2013.

The Kepler spacecraft is currently in point rest mode, having lost a reaction wheel in May. Kepler operated for over four years and met its science goals, and has two years' worth of data in the pipeline awaiting analysis. The two damaged reaction wheels can be turned, but with extra friction; attempts are being made to get back into coarse-point mode; afterwards the mission will attempt to get back to three-wheel mode. If this is not successful, the project will explore what it would take to operate in two-wheel plus thruster mode with new flight and ground software. The Office of the Chief Engineer (OCE) has an agency-wide tiger team that advises projects on developments concerning gyros and reaction wheel lifetimes. The reaction wheels for Kepler did in fact function as long as they were supposed to. Dr. Robinson added that this loss was an anomaly traceable to one batch from a particular company.

SOFIA has just completed its 9th flight in 15 days using the GREAT instrument during a southern hemisphere deployment; over 111 proposals were received for its next science campaign. Five sounding rockets were launched in FY13. There will be two Senior Reviews in calendar year 2014; one for missions (March) and one for archives (April).

The President's budget request for APD is \$649M. The Operating Plan, while not final, is assuming a 7% reduction in available funds. The APD strategy to cope with the shortfall includes reducing carryover from operating missions, re-phasing unneeded FY13 reserves, re-phasing R&A funding, and slowing the development of current and future Explorer missions. There will be some specific impacts in R&A due to the 2013 sequestration; i.e. fewer selections and delaying new funding starts in a number of programs. A 2014 sequestration would have an even greater impact along the same lines.

The President's FY14 budget request includes operation of all missions identified in the 2012 Senior Review. APD has also implemented recommended efficiency measures for Fermi, and will not support selections for the 2012 Explorer Mission of Opportunity AO. APD's near-term strategy is to continue the AFTA study, as well as two versions of an exoplanet mission in the \$1B class. The division will be starting a study on an x-ray probe in the \$1B cost range to determine how much IXO science can be done. APD will submit these reports to the NRC Committee on Astronomy and Astrophysics (CAA), and in Spring 2015 should have a letter of response from the NRC. APD is also keeping track of the European Space Agency's L2/L3 process. Dr. Luhmann asked what fraction of R&A money goes into these SDT reports. Dr. Hertz noted that NASA is paying travel expenses, but not salaries. SDT efforts comprise a few days of work per quarter by the SDT members.

Dr. Peterson reported on Astrophysics Subcommittee (APS) status and issues. The subcommittee remains concerned with NASA's buying power for APD, which supports just a quarter of the Decadal Survey priorities. It is clear that science goals must be revisited within the current budget realities. SMD is managing its budget with short-term solutions, an approach that will cause accumulating problems.

APS established a Roadmap team in February 2013 and has met face-to-face on two occasions. The team has received 82 science abstracts and 24 technology abstracts. A presentation of the final draft will be

given in November, and the final report is to be released in mid-December.

APS is concerned about keeping JWST on track and on budget, and maintaining budget profile, and is closely monitoring the science productivity of SOFIA. APS also notes that the proposed AFTA mission is compromised in two areas: there is no H band, and the coronagraph will be hard to use with an obscured aperture.

Discussion with the Administrator

NASA Administrator Charles Bolden dropped in to the proceedings, thanking the Science Committee for its service. He acknowledged that it is a bad time for SMD scientists, and assured members that NASA is trying to do the best it can with what it has for the science community. The House side of Congress is very unhappy with the state of PSD. However, NASA needs to establish an appropriate cadence for its highest priority activities or it will lose public support. Currently the Agency is focused on plans to get humans to Mars, and must accomplish many things over a long time period. Discovery and New Frontiers must get back on cadence. NASA will probably see budgetary changes to get back to some regular pattern of flying. The days of large Flagship missions are gone for a while. OMB is not happy when NASA does large missions. ARM is an opportunity to advance technologies to get to Mars, with the development of solar electric propulsion (SEP) capabilities. The satellite industry is very interested in solar arrays. Increasing the identification and characterization of NEOs is mandatory. It would be phenomenal to execute a robotic mission that demonstrates a way to change an asteroid's path; this would be a bonus. The first formal meeting of ARM's mission formulation review took place on July 30. NASA received 402 responses to the ARM request for information (RFI). Public engagement is quite high for this mission.

NASA is now a small player in ExoMars as compared to previously, but the Agency has decided to support the 2016 and 2018 ESA missions. Dr. Robinson asked whether NASA expected other space agencies to send humans to the moon. Mr. Bolden felt that China and Russia were capable of such missions, but that ESA is too financially strapped, as is NASA. Dr. Robinson suggested that NASA lead an effort to go back to moon. Mr. Bolden responded that this effort would be folly unless Congress decides to fund it. There is nothing in the budget runout that supports a human lunar mission. That is why establishing a cadence of activity is important.

Dr. Peterson asked what the community might do to control potential damage to SMD EPO and IT programs. Mr. Bolden felt that EPO packages varied in quality, and noted that the President has asked that all STEM-related agencies use the National Science and Technology Council's Committee on Science, Technology, Engineering and Math (CoSTEM) as a conduit for their output. Outreach is a skill- some people do it well and some don't. The Science Committee can help SMD consolidate its outreach effort without requiring every mission to create an outreach plan. NASA needs to move toward optimizing education starting today. There is no change for 2013 in EPO and IT, however it is likely that the Agency will be getting a CR on 1 October. Dr. Urry remarked that as NASA has had extensive experience with EPO, the Agency might consider studying previous programs to determine what works and what doesn't. Mr. Bolden noted that NASA has reached out to the Department of Education, offering its experience. All government agencies are trying to migrate to the direction that comes from CoSTEM. The Department of

Education recently funded NASA to take part in a program called “Let’s Read! Let’s Move!” NASA supported the event, and the Department of Education received recognition. The idea is to take the best in government and make it available to everyone. NASA must take a critical look at how it currently does Education and Outreach in SMD, and SMD should come up with an overarching program that can inform the in-house Education office, giving it the data it needs from science missions. There are fewer assets, and NASA must figure out how to use them.

Dr. Green noted that while SMD possesses the expertise, the division should be responsible for the content so that the resultant STEM products can be used appropriately. Mr. Bolden agreed, and also requested advice on the utility of extended missions (EMs); i.e. how long should the Agency spend millions to squeeze the last data out of these missions. Dr. McComas compared EMs to well-functioning old cars that continue to provide many years of service for little additional cost and commented that EMs actually provide a large fraction of SMD’s science results. He noted that if the goal is to launch more missions regardless of cost and loss of science results, though, funding would have to be diverted away from EMs.

Mr. Bolden noted that attracting young talent requires new missions. Dr. Urry commented that NASA gets into trouble when the public decides what is interesting for NASA to pursue. Congress gives NASA dollars to spend on communities, and specific science goals must be kept in mind. Dr. Hinners commented that NASA has a penchant for self-immolation with regard to large projects such as JWST and MSL- where is the drive for fiscal discipline for future missions? Mr. Bolden felt the recent adoption of the Joint Confidence Level (JCL) process, demonstrating a confidence level of 70% on cost and schedule, has yielded good results. MAVEN is a good example of the practice. He acknowledged that SMD suffered fiscally to get MSL to Mars, and understood that JWST must remain within bounds; the mission is now 14 months ahead on the critical path. He felt also that the communication from the top of the Agency down has been that both cost and technical successes are important. The American people must trust NASA, and NASA must deliver on promises it makes to the community.

Lunch Talk

Dr. Mark Robinson presented a lunch talk featuring imagery from the Lunar Reconnaissance Orbiter mission.

JWST Status

Dr. Eric Smith provided a status on the JWST program. Changes since last NAC meeting have been largely on the programmatic side. Dr. Geoff Yoder has moved on, and Dr. Smith is now acting director. The program has had all hands meetings with critical contractors, and is continuing its regular updates to the Hill. There is weekly contact with senior management at all contractors. The program has also invited GAO and SRB members to Flight Program Reviews on a quarterly basis. Re: cost and schedule, the program continues to receive Earned Value Management (EVM) data for industrial partners, and has asked an independent group to assess schedules.

The near-infrared camera (NIRCam) optical module was delivered last week, and the NIRSpect instrument is in final testing mode, and on schedule to meet its September milestone. The Optical Telescope

Simulator (OSIM) has been certified. Nine of 18 primary mirror segments are at Goddard Space Flight Center, and the remainder are due by December 2013. The spacecraft's sunshield engineering template layers have been delivered, and 80% of subsystem critical design reviews (CDRs) are complete. The Spacecraft Element CDR is scheduled for December. Mass margin problems have been solved, and 85% of the observatory mass is now beyond CDR stage and in fabrication, assembly, or integration and testing. The launch date remains unchanged for October 2018. Schedule reserve is still holding above the planned reserve posture. High-level milestones established since the 2011 replan are now reported monthly to various stakeholders. Milestones that have been deferred do not affect the launch schedule. FY13 milestones have been largely done on schedule; however, one of two milestones that had been deferred from FY2012, the mid-infrared instrument (MIRI) cryocooler cold head assembly (CHA) schedule, has been moved into FY2014. The path to the Spacecraft Element CDR includes many subsystem critical design reviews and they are proceeding well

The MIRI cryocooler issue has existed for some time. The first issue had been technical - leaky cryo valves that had needed to be re-manufactured - and this issue is solved. The challenge that has caused a schedule slip is a mismatch between Northrop Grumman (NG) and JPL schedules. JPL does the end-to-end testing. NG has changed its management team completely and has added personnel. The reason for the mismatch is related to a technical development item. NG successfully demonstrated the cryocooler's performance in 2007, and subsequently tried to improve on the design, which got out of hand. The cryocooler is currently operating to a "green light" schedule, and is working to a very specific distance from the critical path (a couple of months). Another issue exists with the nonexplosive actuators, which hold the telescope down for launch. Right now they are generating too much shock during release and need some redesign. This is not a new technology, but an engineering challenge.

For the NIRCam test and delivery schedule, the program is reworking tantalum caps on boards.. The delivery of NIRCam electronics, NIRSpec, and flight delivery to ISIM are all items that are being closely watched. A top management concern is low FY14 Unallocated Future Expenses (UFEs). There is between 13-15% remaining reserve left for 2013, and 60% of the project's UFE is liened for the following year. If ISIM testing goes smoothly, this reserve should be sufficient. Dr. McComas requested more detailed charts on budget reserve for the next meeting.

Heliophysics/HPS

Dr. Jeff Newmark presented a status of the Heliophysics Division (HPD) in place of Ms. Vicki Elsbernd. The Heliophysics System Observatory (HSO) currently has 19 operating missions. The Interface Region Imaging Spectrograph (IRIS) mission launched on 27 June and is in first light mode. IRIS will provide fine-scale structure and dynamics in sun imagery. The Magnetospheric Multiscale (MMS) mission is scheduled for launch in late 2014/early 2015. Solar Orbiter Collaboration instruments are on schedule to meet the 2017 ESA launch date. Explorer missions ICON and GOLD are scheduled for launch in 2017. Solar Probe Plus is in extended phase B, developing technology to TRL 6 levels. Solar Orbiter is due to have an instrument baseline review in the next few weeks. Recent highlights in HPD include a sounding rocket mission, Daytime Dynamo, launched from Wallops Island, which released lithium vapor in the upper atmosphere to illuminate neutral winds. The research range has various activities in preparation for the LADEE launch.

Voyager 1 is now more than 11 billion miles from the sun, becoming the first human-made object to reach interstellar space; this is still a discovery space for the 40-year old spacecraft, as it maps out the edge of the heliosphere. Signs of interstellar arrival are still to be seen. The Interstellar Boundary Explorer (IBEX) is providing views of the solar tail. IBEX has just completed a Senior Review based on both scientific merit and its contributions to the mission observatory. There has been effectively a 14% decrease in the funding of the 14 operating missions. Dr. Hinners asked how HPD decides to allocate funding to operating missions. Dr. Newmark responded that some of this pressure comes from Congress. Trades are both externally and internally driven. A significant fraction of science is represented by these continuing missions.

Senior Review findings and rankings were briefly discussed. ACE and WIND are providing valuable science, and Voyager continues to provide a unique resource. THEMIS continues to produce good science data. The Heliophysics Roadmap will be completed by Summer/early Fall 2013, working with some differences having to do with Decadal Survey assumptions on the budget. The Roadmap is conservatively assuming a flat budget into the future, with no new starts until 2018/19. The highest priority Living With a Star (LWS) mission is not possible within next decade; it would take 20 years to carry out the Decadal Survey's high-priority missions. The Roadmap is hewing to Survey guidance, and delaying strategic missions, among other things. Asked about the Deep Space Climate Observatory (DSCOVR) mission, Dr. Newmark commented that this would be a discussion for the Joint Agency Satellite Division (JASD), as HPD is not involved in its execution. Noting some budget numbers of \$100M/year that did not represent real research, Dr. Newmark explained that HPD also bookkeeps money for civil servant salaries, and for such things as supporting infrastructure for mission operations (\$5-10M per year); this is not a real increase for HPD.

Dr. Hagan presented a Heliophysics Subcommittee (HPS) update. The subcommittee has not met since April 2013; its next meeting is scheduled for September 17-18. Its current activities include a review of the draft Heliophysics Roadmap, due to be released by the end of September. The final report will be presented to the Science Committee. Dr. McComas encouraged Dr. Hagan to circulate the draft to the Science Committee before its final release.

In terms of aligning the Roadmap with the Decadal Survey, budget is the primary constraint. The Roadmap is proposing to implement the components of the Survey's DRIVE recommendation, which augments the research program. Challenges to this implementation include the fact that the strategic flight missions are very drawn out, and there are no resources to modify resource allocations. HPD may need to consider reducing the cost of missions. The roadmap is also seeking to break out the "real research" line. Even a modest overrun for MMS and Solar Probe Plus (as little as 5%) will be critical to research funding. The roadmap is also recommending that a bigger piece of the pie should be allocated to Explorers over time, redistributed from strategic mission funds.

Science highlights include data from the SUNRISE II solar observatory launched by NASA's Columbia Scientific Balloon facility; this mission is taking measurements of the Sun at solar maximum, to compare with a previous balloon mission launched during the solar minimum. New data on noctilucent clouds

(NLC) has been obtained from the Charge and Mass of Meteoric Smoke Particles (CHAMPS) sounding rocket mission; it has been found that meteoric dust particles serve as condensation nuclei for the formation of these clouds. In addition, the NLC season started on 13 May, a week earlier than any other season observed by the Aeronomy of Ice in the Mesosphere (AIM) satellite. The amplification of these clouds is increasing over time, which may be an indicator of climate change due to methane conversion to water in the upper atmosphere. Dr. Newmark added that these NLC also develop over a very narrow temperature range and occur in a very thin layer of the atmosphere. NLCs also alter the chemistry of solar particles that impact the Earth's atmosphere.

Earth Science Division/Earth Science Subcommittee

Dr. Mike Freilich, Director of the Earth Science Division (ESD), gave an overview of recent events. The division has completed its 2013 Senior Review, and continues to operate a constellation of 16 missions. Jason 1 recently completed its mission and has been terminated as of 1 July. The Landsat Data Continuity Mission (LDCM), now called LandSat 8, launched in February and has completed its commissioning phase. SORCE, which measures solar irradiance, flying since 2003, has had power problems, and is down to its last battery cell. ESD will probably lose SORCE within a few years, but will continue to measure solar irradiance through ACRIMSAT.

Jason 1 was a precision radar altimeter, and provided sea surface elevation measurements for 11 years, well beyond its three-year design life. Jason-2 remains in a precision altimetry orbit. NOAA will be launching Jason-3 in the future. The Earth Science budget is slightly above the previous two years of requests, reflecting programmatic stability. Key budget features remain the same; the flight portion of the program is about 62%. The budget contains additional scope: design and development of a sustained land-imaging system, in partnership with US Geological Service; expansion of the Venture-class competitive flight program; and the development of a program for the Total and Spectral Solar Irradiance Sensor (TSIS), Ozone Mapping & Profiler Suite (OMPS)-Limb, and Clouds and the Earth's Radiant Energy System (CERES) instruments, with a \$40M one-year augmentation in FY14.

CYGNSS is the first of the small-satellite Venture-class competitive missions in development. It will fly in a tropical orbit, measuring reflections of GPS sensors on the ocean, providing data on wind speeds in tropical cyclones for enhanced prediction of storm intensity. The mission has passed KDP-B and has moved into phase B. SAGE-III, an occultation instrument, will fly on ISS; ESA is providing a pointing platform for this mission. ESA difficulties have caused NASA to slip the SAGE-III launch to the first quarter of 2015. Future solicitations for Venture-class missions remain on schedule; the next solicitation is to be released on 7 August, per a planned 18-month schedule. ESD is waiting for the Indian Space Research Organization to sign an agreement to begin the L-band SAR mission.

The current House Appropriations text deletes funding for land-imaging in the FY14 budget, including that for the OMPS-Limb, CERES and TSIS, DSCOVR's Earth-observing sensors. The Senate Appropriations text generally follows the President's request. The President's request supports development of baseline algorithms and initial research funding for DSCOVR. The next launches in ESD

will be that of Global Precipitation Measurement (GPM) in February 2014, Orbiting Carbon Observatory-2 (OCO-2) in July 2014, Soil Moisture Active Passive (SMAP) in October 2014, and SAGE-III in 2015. In addition, seven more missions are funded and on track to launch after 2015 and before 2021. ESD continues to utilize ISS where it makes sense; this includes plans for small science missions such as a lightning image sensor, a coastal imaging instrument, and a scatterometer.

ESD has upgraded its long-range P-3 aircraft and is also using high-flying, heavy lift ER-2 aircraft (a civilian version of U2) in its airborne fleet. A Student Airborne Research Program DC-8 flight activity was recently completed, involving 32 junior and senior undergraduates, who designed aircraft flights and are now analyzing data. This activity was supported by the Dryden, Wallops, Langley and Ames facilities. NASA continues to fly unmanned aerial vehicles (UAVs) in the Arctic, but lost one aircraft over the ice on the Beaufort Sea in late July. The SEAC4CRS experimental mission is now flying out of Houston instead of Thailand and Indonesia, owing to local political tensions. There is SEAC4CRS connectivity with other experiments, including NOAA's measurements of atmospheric aerosols (SENEC), and DOE forest fire measurements. ESD is getting maximum scientific utility from these measurements. Remotely piloted Global Hawk HS3 missions are flying sequentially to study hurricane formation, including the Sahara Desert's dust contributions to hurricane development.

Science highlights include data on ice-shelf melting around Antarctica, indicating that ice shelves lose the most mass to melting as opposed to calving. It has also been found that the Ross and Weddell seas are melting the least. These results are derived from a combination of data from other nations' SAR data, radar from both ground-based and airborne sources, and models. There is new data from observations of the Thwaites Glacier on how ice flows under the ice sheets, based on specular measurements.

Dr. Tapley reported on the status of the Earth Science Subcommittee (ESS). ESS has not met formally since the last meeting of the SC. The subcommittee has been reviewing SMD 2014 Science Plan, carrying on a dialogue with the NAC IT Cyber-Infrastructure Initiative, and remains concerned with ESD's ability to make long-term measurements. ESS has issued previous findings on the continuity of measurements, which are needed for climate-related issues and modeling of data. A plan is needed to ensure the continuation of important satellite-determined climate data records. ESS has also issued a finding/observation on the ESD budget reduction, offering guidance to reduce funding for specific program elements rather than taxing the entire ESD. Dr. Freilich noted that NASA has requested a major study from the NRC on the continuity issue. Asked if there were coordination between US satellites and international assets, Dr. Freilich reported that ESD does a tremendous amount of coordination on the A Train satellite group, which includes Japanese and French spacecraft. JAXA is involved with GPM. Furthermore, ESD plays a consistent role in the international coordination bodies, Committee on Earth Observation Satellites (CEOS), and contributes to the Coordination Group for Meteorological Satellites (CGMS). All of the data are free and openly available in the archives. NASA insists that international collaborators make their data available. Dr. Freilich offered to brief the SC on this subject in future meetings.

Planetary Protection

Dr. Eugene Levy, Chair of the Planetary Protection Subcommittee (PPS), gave a status of the

subcommittee's work. PPS has a new Executive Secretary, Gale Allen. PPS continues to assess programmatic adherence to PP requirements, responding to substantive and perceptual concerns. Substantive concerns include potential forward and backward contamination in the course of space exploration. Backward contamination risks are associated with safeguarding the terrestrial biota, and ensuring public health and safety. Forward contamination controls are aimed at protecting future science investigations. There are and have been issues of contention in the NASA enterprise with respect to PP protocols. Research suggests that life appears to have arisen early in Earth's history, given the ability of extremophiles and the range of habitats in which they can survive. The existence of extremophiles suggests that life may be more common than believed, that it may be able to survive in more extreme environments than currently known, and that terrestrial life may be more robust than once commonly viewed. Dr. Hinnert commented that extremophiles may well have evolved into these extreme environments. Dr. Levy noted that there is a view that it seems likely that the environment in which terrestrial life originated was a much more highly disequibrated environment than previously thought. The point is that no one knows with certainty the limits of the conditions for life.

PPS has recommendations to be transmitted to NAC; the first that PP requirements should be an integral part of mission planning and implementation from the outset. PPS met 29-30 April and discussed at length the adequacy of PP implementation, particularly with respect to the MSL experience and Mars 2020 mission planning. PPS is recommending an adjustment of this practice so as to avoid late-stage, contentious overlay of PP requirements on a project. PPS therefore recommends that PP be incorporated into mission design, hardware and science operations from the outset, and that the Planetary Protection Officer (PPO) be included in mission planning, ensuring a more collegial interaction between the mission and PPO. Dr. Cassie Conley offered some background on MSL difficulties in response to a question from Dr. Urry. PPS further recommends that personnel working on special region projects be better trained and sensitized to the importance of planetary protection. NASA currently lacks the resources to provide this training, but adoption of the recommendation would provide positive risk/cost benefit. Dr. Conley provided more background on the broader purview of PP, which touched upon policy, technology, science and implementation, and the status of recent PPS recommendations. The PPO has received good feedback from JPL efforts on Lessons Learned on MSL.

Public Comment period

The SC paused for the public comment period. No comments were noted.

Discussion of Findings and Recommendations

The committee discussed findings and recommendations to be transmitted to the NAC, including IT, EPO and the recent EPO restructuring and two PP recommendations, as well as the value of extended missions to the science community. While the discussion involved no particular matters, each committee member identified their science affiliations with various missions. [McComas (IBEX, TWINS, ACE); Urry (HST); Tapley (GRACE); Pieters (Dawn); Robinson (LRO and MESSENGER); Hagan (US PI on GO-CHE); Luhmann (Cassini, Venus Express and STEREO); Peterson (HST and Chandra)]. Dr. Feeley noted that particular matters were not under discussion and advised that the meeting proceed without recusals.

Dr. Hagan reiterated concerns with the alignment the Heliophysics goal in the NASA Strategic Plan and the serious implications for the HP portfolio, and suggested the SC examine the SMD white paper in which this concern was dismissed. Dr. Levy questioned the need for unique alignments. Dr. Urry noted that this particular complaint could apply to any division. Dr. McComas felt that one issue seemed specific to Heliophysics, and the other more general to the view of SMD. Dr. Urry suggested adding to this issue the disconnect between the Agency-level Strategic Plan and the science division Roadmaps. Dr. Luhmann addressed the packaging of NASA science in defining NASA missions as possibly appropriate for a finding. Dr. McComas noted that the EPO subcommittee chair, Lars Perkins, talks a lot about the NASA image and making a better impact, and that it might be interesting to meet jointly with the EPO committee. Dr. Urry raised the overall concern about the budget, and the politicization of NASA, commenting that science should be a civil issue. Dr. Pieters remarked that the whole Strategic Plan is linked to OMB, and at some point it is tied to the Presidential term. Dr. Urry felt the SC might do well to convey some sense of principle that would be helpful to NASA; in the budget case, by saying that sharp changes in budget profiles are inefficient. Dr. Luhmann was increasingly concerned about the burden of planning activities on the R&A programs, as there is no compensation tied to participation. Dr. Peterson raised the issue of CME effects on the world's electrical grid, noting that a Carrington-level event could shut down the global grid for months. Dr. Feeley reported that OSTP has put together an interagency group to look at the impact on grid and spacecraft, and took an action to ask Tammy Dickinson to brief the SC on its status. He also referred to Dr. Jim Green's Congressional testimony on space debris threats, in addition to NEOs and CMEs. Dr. McComas suggested that the SC obtain a status on what other groups are doing in this area. Dr. Hagan noted that there is a new AGU group dealing with this issue. Dr. Levy commented that risk mitigation is an important government function better suited to OSTP.

The SC reviewed a softened ITIC finding and reached general consensus on the wording. Dr. Urry recommended that NASA analyze what data is available to support keeping EPO within its current structure. There was much committee discussion on the value and relevance of EPO metrics to the argument. The committee discussed the active resistance to past PPS recommendations and agreed to refine recommendations for the following day, on the science content, particularly with regard to Heliophysics, in the Strategic Plan. Dr. McComas preferred to avoid commenting or deferring on politicization of NASA. Referring to the budget, Dr. Hinnners commented that very large missions have been swamping SMD, and have gotten way out of scope with what the budget mix should look like; there may be something there the SC could grapple with. Dr. Robinson noted that there seems to be no punishment for overruns. Dr. McComas suggested the committee plan for a future briefing on MSL Lessons Learned combined with a briefing on mission balance, as well as a historical discussion of mission sizes.

July 31, 2013

Discussion

Dr. McComas opened with remarks on findings, and reported having spoken with Larry Smarr on developing a joint finding with ITIC. The committee discussed an EPO finding in terms of evaluating best practices, based on an analysis of the effectiveness of past education and outreach efforts at NASA. Dr. Pieters suggested adding a sentence about the potential loss of opportunity, expertise and heritage. Dr. Hinnners posed the question in terms of whether NASA wants to educate the public about space activity or

prepare a scientific workforce. Dr. Feeley noted that goals are already set for SMD and EPO lead; these goals establish the NASA approach and flow down as criteria to programs. Dr. Luhmann remained more explicitly concerned about the loss of science infusion into EPO. Dr. McComas deferred the EPO finding to the next meeting, as the committee could not reach agreement.

The committee developed language for findings on the value of extended missions in light of the constrained budget environment and the need for continuing mission operations; Strategic Plan development; and planetary protection. The SC deferred a finding on PP training to the next meeting.

The SC further discussed issues related to the EPO; Dr. McComas relayed a communication to Lars Perkins on the matter. On the ITIC finding and recommendation, Dr. McComas, felt the committee had concurred with the general tone, and proposed that he work with Dr. Smarr on putting through a recommendation from the ITIC. Dr. McComas adjourned the meeting at 9:48am.

Appendix A
Attendees

NAC Science Committee members

David J. McComas, Southwest Research Institute, *Chair*
Maura Hagan, NCAR, Chair, Heliophysics Subcommittee
Noel Hinners, Consultant
Janet Luhmann, UC Berkeley, Chair, Planetary Science Subcommittee
Eugene Levy, Rice University, Chair, Planetary Protection Subcommittee
Bradley Peterson, Ohio State University, Chair, Astrophysics Subcommittee
Carle Pieters, Brown University
Mark Robinson, Arizona State University
Byron Tapley, University of Texas, *Vice Chair* and Chair, Earth Science Subcommittee
Meg Urry, Yale University
T. Jens Feeley, NASA Headquarters, *Executive Secretary*

NASA Attendees

Barbara Adde, NASA Headquarters
Gale Allen, NASA Headquarters
Marc Allen, NASA Headquarters
Joan Centrella, NASA Headquarters
Catharine Conley, NASA Headquarters
Michael Freilich, NASA Headquarters
Chuck Gay, NASA Headquarters
James Green, NASA Headquarters
Hashima Hasan, NASA Headquarters
Paul Hertz, NASA Headquarters
Lindley Johnson, NASA Headquarters
W. Vernon Jones, NASA Headquarters
Deirdre Jurand, NASA Headquarters
Jennifer Kearns, NASA Headquarters
Dave Klumpar, NASA Headquarters
Peg Luce, NASA Headquarters
Cheryl May, NASA Headquarters
Peter Meister, NASA Headquarters
Michael New, NASA Headquarters
Jeff Newmark, NASA Headquarters
Marian Norris, NASA Headquarters
Adriana Ocampo, NASA Headquarters
Julie Pollitt, NASA Headquarters
Jonathan Rall, NASA Headquarters
Eric Smith, NASA Headquarters
Christy Rivera, NASA Headquarters
Rita Sambruna, NASA Headquarters
Elsayed Talaat, NASA Headquarters
Ray Taylor, NASA Headquarters
Craig Tupper, NASA Headquarters
Lucia Tsaoussi, NASA Headquarters
Mary Voytek, NASA Headquarters
Nicholas White, NASA GSFC

Dan Woods, NASA Headquarters

Non-NASA Attendees

T. Blankenship, Booz Allen

Lamont DiBiasi, SWRI

Daniel Leone, Space News

James Lochner, USRA

Michael Moloney, NRC

Jon Malay, Lockheed Martin

Larry Richardson, ULA

Stephen Squyres, Cornell, *NAC Chair*

Ana Wilson, Zantech IT

Joan Zimmermann, Zantech IT

Appendix B
NAC Science Committee Membership

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

Dr. Byron Tapley
University of Texas (Vice Chair)

Dr. Maura Hagan
National Center for Atmospheric Research

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

Dr. Eugenia Kalnay
University of Maryland

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. Meg Urry
Yale University

Dr. Carle Pieters
Brown University

Dr. T. Jens Feeley
Executive Secretary
NASA Headquarters

Appendix C
Presentations

1. NASA 2014 Strategic Plan Development; SMD Science Plan Status; *Julie Pollitt, Dan Woods*
 2. NASA Science Budget Update; *Craig Tupper*
 3. Finding NEOs Before They Find Us; *Lindley Johnson*
 4. Planetary Science Division Overview/Planetary Science Subcommittee Report; *James Green, Janet Luhmann*
 5. Astrophysics Division Update/Astrophysics Subcommittee; *Paul Hertz, Bradley Peterson*
 6. James Webb Space Telescope Program Office Update; *Eric Smith*
 7. Heliophysics Division/Heliophysics Subcommittee Report; *Jeff Newmark, Maura Hagan*
 8. Earth Science Division/Earth Science Subcommittee; *Michael Freilich, Byron Tapley*
 9. Planetary Protection Office/Planetary Protection Subcommittee; *Catharine Conley, Eugene Levy*
-

Appendix D
NAC Science Committee
July 29-31, 2013

Agenda
(all times EASTERN)

Monday, July 29 (MIC-7/Room 7H45, unless noted)

- | | |
|--------------------|--|
| 1:00-1:15 pm | Opening Remarks -- J. Feeley/ D. McComas |
| 1:15-2:15pm | NASA Strategic Plan/SMD Science Plan Status -- J. Pollitt / D. Woods |
| 2:15-3:15pm | Discussion (esp. SMD Science Plan) |
| 3:15-3:30pm | Break |
| 3:30-4:00pm | Budget Status -- C. Tupper |
| 4:00-5:00pm | NEOs & Planetary Defense -- J. Green / L. Johnson |
| 5:00-5:30pm | Discussion |
| 5:30-5:45pm | First Day Wrap-up -- J. Feeley/ D. McComas |
| 5:45pm | Adjourn for the day |

NAC Science Committee
July 29-31, 2013

Agenda
(all times EASTERN)

Tuesday, July 30 (MIC-7/Room 7H45, unless noted)

8:30-8:40am	Opening Remarks/Announcements – J. Feeley / D. McComas
8:40-9:40am	Planetary Science / PSS – J. Green / J. Luhmann
9:40-10:10am	Planetary Protection / PPS – G. Levy / C. Conley
10:10-10:20am	Break
10:20-11:20am	Astrophysics / APS – B. Peterson / P. Hertz
11:20-11:50am	Discussion
11:50-1:00pm	Lunch on Own
1:00-1:30pm	JWST Status – E. Smith
1:30-2:30pm	Heliophysics / HPS – M. Hagan / V. Elsbernd
2:30-2:45pm	Break
2:45-3:45pm	Earth Science / ESS – B. Tapley / M. Freilich
3:45-3:50pm	Public Comment
3:50-5:20 pm	Discussion, Findings and Recommendations
5:20-5:30pm	Second Day Wrap-up – J. Feeley/ D. McComas
5:30pm	Adjourn for the day
