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MEETING REPORT

Bradley Peterson, Chair

Elaine Denning, Executive Secretary

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Welcome and Introduction

Science Committee Executive Secretary, Ms. Elaine Denning, called the meeting to order and made administrative announcements. She introduced Dr. Bradley Peterson, the incoming Chair for the NASA Advisory Council (NAC) Science Committee (SC).

Members introduced themselves around the table. Dr. Steve Squyres, NAC Chair, commenting briefly, expressed his deep gratitude for the work performed by the Committee and the discipline subcommittees.

Research and Analysis Two-Step Proposal Data

Dr. Max Bernstein presented a briefing on the adoption of a two-step proposal process for the Science Mission Directorate (SMD) Research and Analysis (R&A) program's Research Opportunities in Space and Earth Sciences (ROSES) solicitation, providing background and preliminary data on selection rates. ROSES is an omnibus solicitation for small grants, and allows for some variation in how proposals are processed. There is an optional notice of intent. More recently, ROSES has instituted the requirement of a brief summary of the research being submitted, including information about team members. This is called a Step-One proposal.

In the past, SMD has rarely if ever required any notices of intent (NOIs) or Step-One proposals. Only the Earth Science Division (ESD) has required NOIs in a relatively small call in the Land Cover/Land Use Change ROSES calls. The two-step process gained attention when the National Science Foundation (NSF) began to use the process in 2012 for its biological grant program, a program about as large as ROSES. NSF had been routinely looking at a 10% selection rate, which was considered inefficient in terms of writing and reviewing proposals. The two-step process was designed to make decision-making more efficient by allowing a first-pass evaluation in a Step 1 proposal, providing a triage approach to selection. The NSF allowed only the top half of evaluated proposals through in the Step 1 proposal. After NSF briefed NASA on its two-step process, Dr. Bernstein felt the original NSF approach to be relatively unforgiving, and decided to adapt its two-step approach somewhat. The two-step process was eventually tested with the ROSES Cassini Data Analysis Program (CDAPS), using a 3-page Step 1 proposal, and enabling proposers to submit a full proposal whether or not the Step 1 was encouraged or discouraged. Normally only 50% of proposers submitted an optional NOI, however a Step 1 proposal is required so the agency knows what is coming in and can construct the panel in advance. Dr. Bernstein found that there was a good correlation between Step 1s and Step 2s in terms of quality. However, he noted that one proposal did poorly in Step 1 while doing well in Step 2, and in fact was funded. This was one case in 100, but it raised concerns about completely barring a discouraged Step 1 from further consideration, as in the NSF method.

The difference between barring and discouraging a Step 1 proposal is significant because mere discouragement is more forgiving of error or uncertainty; it also allows for a fast internal evaluation based on programmatic factors or relevance, rather than a rigorous merit evaluation; and because legally, the feedback given to the proposer must be generic because ROSES is an ongoing procurement. An important caveat here is that reviewers of Step 2 proposals are never told whether the Step 1 was encouraged or not.

Examples from a Heliophysics Division (HPD) 2013 ROSES call were presented. Of 306 Step 1 proposals, 12 were discouraged because they were deemed as noncompliant; 294 (96%) were encouraged. For the HPD Guest Investigator (GI) program, 174 Step 1s were submitted; of these 73 were encouraged, and 83 submitted. 22/83 were selected (24%). The discouragement made a difference to the proposers. In 2013, no discouraged proposals were selected for funding at Step 2; it seems that Step 1 evaluations were adequately predictive. In 2014, in a HPD Supporting Research call, 323 Step 1 proposals were submitted, and 168 were encouraged. 221 Step 2 proposals were submitted, resulting in an 18% selection rate. Of the proposals discouraged at Step 1, 28% were competitive and 11% were funded at Step 2. Of proposals encouraged, 38% were competitive and 20% were funded. These numbers suggest that Step 1 is a fairly good but imperfect predictor (e.g., 1/3 of proposers submitted a Step 2 and only 10% were successful). In this case, there were no multiple proposals from one principal investigator (PI), as this is not permitted in HPD, except for special cases. Multiple proposals from one investigator are allowed in the Planetary Science Division (PSD), hence the attrition rate between and Step 1 and 2 is higher, probably for this reason.

The PSD research program was restructured in 2014; core calls were reorganized based on themes rather than targets (Mars) or objects (atmospheres, geology). After this change, PSD required a one-page Step 1 proposal for a "relevance check." In its initial call, PSD discouraged 100 out of 1500 Step 1 proposals, but redirected discouraged proposals to other calls within PSD based on relevance. No Step 1s were evaluated for merit. For the Planetary Data Archiving, Restoration, and Tools (PDART) call, there were 143 Step 1 proposals, 14 of which were discouraged and redirected. Of the 129 encouraged, only 100 Step 2 proposals were received, while 5 more came in from other programs. Twenty-three of the 105 Step 2 submissions were selected. What is interesting is that 2 of the 5 that came in from other programs were selected for funding, therefore it seems that the redirection worked. Another example is the CDAPS program. In ROSES-2014 of the 100 encouraged at Step 1, 78 were received as Step 2 proposals, and 18/78 (23%) were selected. Moreover, two proposals that were submitted to and reviewed by the Solar System Workings program and were found to be of excellent Merit were forwarded to CDAPS. These were assessed by the program scientist for Relevance, and were also funded by CDAPS.

Currently, all ROSES calls for Heliophysics, most calls in Planetary Science, and a few calls in Astrophysics are using a version of the two-step process. Most merely require a brief one pager on research that is planned, and proposals may be submitted whether they are encouraged or not.

Dr. Peterson noted that he is currently sitting on an Astronomy and Astrophysics Advisory Committee (AAAC) task force that is looking at selection rates in Astrophysics, a discipline that typically receives a much larger number of proposals. Because money simply isn't available, a pile-up of excellent proposals is occurring in the field. The task force was created to address this matter. Dr. Peterson encouraged Dr. Bernstein to look at AAAC's preliminary report. Dr. Bernstein agreed, and added that in order to keep up with inflation one should increase award size, but that with a fixed budget this will inevitably also result in lower selection rates. Dr. Harlan Spence commented that concerns about award sizes are cropping up in the Heliophysics and other areas, such that one may expect to see researchers leaving the field across various disciplines. Dr. Peterson noted that in the case of NSF, a mismatch between

supporting facilities vs. people has placed a burden on research funds. Asked by Dr. Spence about any trends or lessons learned in the HPD ROSES call, Dr. Bernstein thought that HPD should look at specific programs and absolute numbers, not just percentages, while there is not yet enough data to determine any trends. He still believed he could determine which programs would benefit most from the two-step process; a focused call, on the other hand, inherently discourages other proposers. A focused call may not benefit from a two-step process. Dr. James Green felt that calls varied more based on the composition of panels. Dr. Peterson suggested that Dr. Bernstein consult with Dr. Hashima Hasan as Astrophysics produces a lot of data on this.

Ad Hoc Big Data Task Force

Dr. Erin Smith, Executive Secretary of the Ad Hoc Big Data Task Force, presented an update on the progress of the effort. The final membership is being determined, including leading authorities on big data, particularly in science, from academia, industry, and all four of the SMD domains. All nominees have backgrounds in utilization or administration of large-scale data archives. A broad call for nominations resulted in 70 candidates, after which the process was reviewed several times, incorporating recommendations from the NAC SC to specifically include more industry representatives. The Chair specializes in cyberinfrastructure; in addition there is one representative from aerospace, two from industry, and six discipline representatives - two each from Earth Science and Heliophysics (climate change, Earth and space weather, real-time analysis and informatics), and one each from Astrophysics and Planetary Science. The membership roster reflects the prevailing belief that academic institutions are driving the discipline, because industry's big data interest is focused more on marketing, etc. The nomination package is complete and is in the approval process, and preliminary contact of nominees has begun; the process similar to that for an appointment to an advisory committee.

Asked by Dr. Peterson if special government employees (SGEs) were to be included on the Task Force, Dr. Smith explained that yes, this will be the case. However, as the Federal Advisory Committee Act (FACA) allows for another level of participation called the "representative level," industry partners may be treated as such to expedite matters. Next steps are to complete a consultation with the NASA Administrator, complete a review of conflicts of interest, and prepare appointment documents, with the goal of having a first meeting in September 2015, with a minimum of 5 members to function as a quorum.

The key motivator for the Task Force is to seek ways to increase the interoperability of data, and to enable the use of data for real-time decision-making, which can result in completely new and actionable science information. In practical terms, such an effort will need to deal with broadband access and security. Dr. Peterson asked if the Task Force included *ex officio* members from the National Oceanic and Atmospheric Administration (NOAA) and the US Geological Survey (USGS). Dr. Smith replied that there is one representative from USGS and no one from NOAA, but some Heliophysics representatives have had experience with NOAA, through the Joint Agency Satellite Division (JASD) and Space Weather Task Force, as well as the Applied Earth Science program. That said, the Task Force is more focused on science rather than operations. Dr. Robert Lindberg added that there are representatives of 5 agencies on the Planetary Protection Subcommittee.

At present, the Terms of Reference (TOR) document is signed for a term of 2 years. The charter language includes the intent to explore the existing and planned evolution of NASA's science data cyber-infrastructure; to catalogue best practices at NASA and in industry and academia; and to investigate federal initiatives related to big data. The Task Force Chair will report regularly to the NAC SC. Challenges to the effort include the lack of a crisp definition of big data. The term signifies different things to different disciplines, and encompasses questions of engineering and architecture, how to access and store large databases, as well as data rights, internet providers, and cybersecurity, training and communications, visualization of data, and prioritization. What tools do we need, have, or must develop? How do we start asking the right questions?

The Task Force will address a list of discussion topics:

- What/where are the opportunities in finding synergies in application of big data across NASA disciplines?
- Are there any particular areas that could benefit from the work of the Task Force?
- What kind of linkages between science disciplines should be established?
- What kind of products should TF produce?

Dr. Peterson commented that the answers to these questions should be provided by the Committee, and suggested that the SC have an initial discussion before pitching the problem to the subcommittees; ideally, the goal would be to have answers from subcommittees before the next SC meeting. Dr. Mark Robinson felt that the Task Force goals and objectives were unclear, and that they must address issues such as data collection and archiving, calibration, value-added products, accessing, and making sense/enabling science from big data. For spacecraft, the Planetary Data System (PDS) has remained unchanged for decades. The Lunar Reconnaissance Orbiter (LRO) camera has collected more data than all planetary missions in history. In the past, NASA has stored calibrated data, which rapidly become stale. Whose decision is it to make value-added products? What happens as we get smarter about data? Dr. Scott Gaudi asked what problem the Task Force is trying to solve. Dr. Smith explained that NASA was asked to assemble the Task Force to respond to federal initiatives that deal with climate change, and also to make NASA data sets more available to non-NASA users. She felt that a catalogue of what SMD is doing in big data would be a useful product in and of itself, and might identify new questions to address, and solutions to pursue. Dr. Peterson noted that Astrophysics used to have an initiative for a Virtual Observatory between NASA and NSF, which has disappeared, and that there may be an object lesson in that fact. Dr. Smith said the effort has been renamed the National Virtual Observatory, which just had a status review in March and put out a call for proposals in April. There had been an issue with the agreement between NSF and its counterpart in 2014, which is why NASA had to step in. Dr. Peterson requested having a report from them given that this is what the Task Force will do.

Dr. Lindberg commented that the Task Force seemed to be NASA-centric, and cautioned against losing the opportunity to see the bigger picture. He noted that NOAA and NASA have their own data sets, and pointed out that Wolfram Research has a nascent initiative called Wolfram Alpha, whose objective is to ask unstructured questions from as many data sets as possible. The Task Force should hear from them. Dr. Gaudi said he was skeptical, as often data is disparate and there is an opportunity cost in doing this.

Dr. Peterson said that the APS reviewed archiving, and it might be a good starting point to have a short report on NASA archives.

Dr. Robinson suggested taking a systems engineering approach to what the committee should be working on by stating the need, goal and objectives, and focusing on the tasks and deliverables. Dr. Lindberg recommended focusing on the White House paper that requested the Task Force. Dr. Lindberg raised one question: does the data structure allow future questions to be answered? He made an analogy to LightRoom photographic software, which stores raw data with all the filters applied, and described an example of unintended use, such as detecting near-Earth objects (NEOs) in images taken for other purposes. Dr. Amy Mainzer noted that the Near-Earth Object Wide-field Infrared Survey Explorer (NEOWISE) Infrared Processing and Analysis Center (IPAC) is applying a tool to Spitzer and Herschel data, which can carry out a Solar System query to see whether a particular object had been detected across wavelengths, etc. Drs. Peterson, Lindberg and Robinson took an action to draft some initial thinking to send to the subcommittees.

Discussion

Dr. Peterson raised some unresolved issues from prior meetings, such as the travel restriction issue which had met with a non-concurrence from the Administrator; evidently NASA feels that the travel policy had not been made sufficiently clear at the center level. The center approval process is still inordinately complex, thus Dr. Peterson felt it would be useful go back to the centers and ask them what they can do about it. Dr. Green recommended the provision of a list of rejections and late approvals to illustrate the problem. Dr. Gaudi recounted that the Astrophysics Subcommittee (APS) had discussed the issue and had concluded that the 50-person limit for NASA attendance at foreign conferences does create limits, but that the limits must be accepted as they are law, not simply NASA policy. As to late approvals, the APS felt that APD had done as much as possible to ease these burdens. APD Director Dr. Paul Hertz continues to work with centers on alleviating the problem. Dr. Mainzer cited the experience of colleagues that have been barred from topical conferences. Dr. Green cautioned against whining about paperwork, and suggested confining concerns to the fact that science was being impeded. He felt that publicity about government boondoggles was the basis of the travel restrictions, and that NASA is still struggling against perceptions. Dr. Lindberg suggested asking centers for lists of people who were denied participation in conferences and giving the list to Headquarters as evidence that the interpretation problem persists. Dr. Gaudi felt that monitoring the situation seemed to be the best response. Dr. Peterson concurred, and moved to monitor the situation and determine that there is still a problem, with each subcommittee reporting on approvals, rejections, etc.

Member Research Presentation "The Surprising Moon!"

At lunch, Dr. Mark Robinson provided a science briefing on recent Lunar Reconnaissance Orbiter Camera (LROC) discoveries that point to ongoing tectonism and recent volcanism on the surface of the Moon.

Planetary Science Division Update (PSD)

Dr. James Green, Planetary Science Division (PSD) Director, presented an update on the division via telecon. The division is preparing many missions for launch, including OSIRIS REx (Origins-Spectral

Interpretation-Resource Identification-Security-Regolith Explorer), a sample return mission to the asteroid Bennu. It has recently delivered the Strofio (Start from a Rotating FIeld mass spectrometer) instrument for BepiColombo. PSD is also participating in the European Space Agency (ESA) mission ExoMars (Exobiology on Mars) 2016, and preparing for the next NASA Mars mission, InSight (Interior Exploration using Seismic Investigations, Geodesy and Heat Transport). Outreach and education have been well served by events in planetary exploration in 2014, such as the insertion of the MAVEN (Mars Atmosphere and Volatile Evolution) spacecraft into Mars orbit, the observation of the Siding Spring comet at Mars by numerous NASA assets, the arrival of the Curiosity rover at Mount Sharp, the arrival of ESA's Rosetta Philae lander at comet 67P/Churyumov-Gerasimenko (which included $150M worth of NASA instrumentation and support from the Deep Space Network), and the launch of Hayabusa 2, from which NASA will share in 10 percent of the sample returned from the asteroid (162173) 1999 JU3. This year, Dawn visited Ceres, MESSENGER (MErcury Surface, Space ENvironment, GEochemistry, and Ranging) made its terminal impact on Mercury, and the new Europa Clipper mission had its Step-1 instrument selection. New Horizons made its spectacular flyby through the Pluto-Charon system, and PSD is moving toward a Discovery Step-1 selection in September.

The MESSENGER spacecraft, after 4100 orbits, 6 flybys, and 1504 Earth days (8 Mercury solar days); impacted the planet on April 30, 2015, obtaining a radio profile of Mercury's exosphere as the spacecraft drifted in. The impact went smoothly, occurring at approximately 15.4° latitude, 210° longitude. When BepiColombo arrives in 2021, it will look for the impact site. Science results include the observation of a dynamic magnetosphere, with much reconnection activity. Polar deposits with presumed cold traps were also sighted. Mercury has proven to be a volatile-rich planet, with evidence of global contraction.

Dawn's visit to Ceres began on March 6, when the spacecraft approached its 13,500 km circular orbit. A survey orbit was begun on June 5, which will include both high and low altitude passes. Dawn is currently at 2900 km altitude and will undertake a total of 406 days of operations. The lowest altitude will be 1475 km. Thus far the mission is working well, and bright regions, perhaps indicative of water vapor emission, have been seen. Older, cratered terrains and smoother, younger terrains have been observed. Lower survey orbits may resolve the mystery of the bright spots; at this time there does not seem to be a peak in the main crater of interest; the bright area seems to represent a hole from which water vapor may be emitting. According to the latest measurements, Ceres is about half the size of Pluto.

The Pluto flyby on July 14 was very successful, providing dramatic imagery. The New Horizons spacecraft performed two occultations, one of Pluto and one of Charon, and obtained good light curves in both instances. On Pluto, the yellow icy regions have been determined to contain methane snow. The "heart" contains methane, nitrogen, and carbon monoxide. Very few craters have been seen, and ice peaks the size of Mauna Kea have been sighted.

Discovery and New Frontiers missions, with $450M and $850M cost caps, respectively, are under way. PSD is aiming for 4-5 Discovery missions per decade. Active Discovery missions include Dawn, LRO (Lunar Reconnaissance Orbiter) (operations and management); the Strofio instrument on BepiColombo (launch 2017); and the InSight seismic and thermal mission that will be on Mars in 2016. Discovery and New Frontiers calls will accept any proposal targets in the Solar System, excluding the Earth and Sun.

PSD still has radioisotopic (both radioisotopic thermal generators and radioisotopic heating units) power for Outer Planet missions, and is still supporting Stirling testing and technology development at Glenn Research Center. The New Frontiers program counts New Horizons as its most recent success, while Juno will be arriving at Jupiter on July 4, 2016, while the asteroid mission OSIRIS-REx is to be launched in September 2016. New Horizons will be sending data back over the next year; and meanwhile the Hubble Space Telescope (HST) has identified two objects proposed for flyby. New Horizons will undergo a Senior Review to determine whether or not it should enter into an Extended Mission (EM) phase. The next New Frontiers call (#4) includes 5 opportunities: a comet sample return, Saturn probes, a lunar South Pole expedition, a Trojan tour rendezvous, and a Venus *in situ* explorer. The final release will be made by September of the next fiscal year. New Horizons #5 includes an Io observer and a lunar geophysical network, all as per the recommendations of the Decadal Survey.

The Europa Clipper mission has entered phase A of its development. Its science goals are to explore Europa's icy shell and ocean; composition; geology; and to perform reconnaissance. Europa is about as large as Earth's Moon. The spacecraft will also interrogate the satellite's observed plumes, and will carry instruments that include a plasma magnetometer, camera, ice-penetrating radar, dust analyzer, and ultraviolet spectrograph. Operations will employ multiple flybys to deal with the harsh radiation environment (similar to how Cassini orbited Titan) in order to obtain a global map of Europa.

Mars exploration during this decade will see NASA working with the Indian Space Research Organisation (ISRO) on its Mars Orbiter Mission (MOM), and with ESA on the Trace Gas Orbiter (TGO). NASA missions MAVEN, Opportunity, Curiosity, the Mars Reconnaissance Orbiter (MRO), and Mars Odyssey will continue. The Mars 2020 mission has completed its Key Decision Point-B (KDP-B) milestone and has signed agreements with international participants, and is making great progress. The sampling and caching architecture has been defined and a development laboratory and testbed have been established. A second landing site workshop is being held in August of this year, and a flight system design freeze will be imposed at that time. Beyond 2020, there will be an emphasis on working with the Human Exploration and Operations Mission Directorate (HEOMD), leveraging entry, descent and landing (EDL) capabilities, and continuing surface exploration on Mars. The 2020 heat shield will carry instrumentation to enable a better understanding of entry dynamics. Mars 2020's Mars Oxygen ISRU Experiment (MOXIE), which will extract oxygen from atmospheric carbon dioxide, is the first *in-situ* resource utilization (ISRU) collaboration between PSD and HEOMD. A number of joint studies with both HEOMD and the Science and Technology Mission Directorate (STMD) are also ongoing for Mars exploration. One pressing issue is that the Mars telecommunications infrastructure must be replaced to support future missions.

The first human landing site workshop will be held in October 2015 at the NASA Lunar and Planetary Institute (LPI). The next mission after 2020 appears to be an orbiter for telecom, which is still in definition phase.

Dr. Robinson asked about the status of a proposed CubeSat and landing element for the Europa mission. Dr. Green replied that JPL studying this option, as there are 250 kg of mass available for launch on an Atlas V or the Space Launch System (SLS), which is enough for a small element to be dropped off to

interrogate Europa's plumes. These are all part of trade studies. Dr. Spence commented that the Moon is a good stepping stone to Mars in terms of studying radiation environments, and that there seems to be an opportunity to take current data and apply it to Europa. Dr. Green noted that there is an opportunity to add two teams to the Europa mission - one is gravitational and the other is radiation. The Clipper will carry dosimeters, and Dr. Green reported having asked the community to apply, particularly researchers in Heliophysics, to help advise the project on the placement of sensors, etc. New Horizons observed five coronal mass ejections (CMEs) that made it to the Pluto environment just around the encounter time, and new data are expected to be uncovered. Astrophysics also had many assets trained on Pluto, including the Stratospheric Observatory for Infrared Astronomy (SOFIA) (occultation with a bright star); PSD has been working hard with other divisions to connect assets.

Curiosity Update

Dr. Ashwin Vasavada, Project Scientist for the Mars Science Laboratory (MSL), presented a briefing on the MSL mission, which is beginning its fourth year of operations on the surface of Mars. Hundreds of rock and soil analyses have been carried out. The rover has discovered an ancient lakebed at Yellowknife Bay, reached basalt rocks at Mount Sharp, and found all the elements that life requires, as well as different redox conditions. Samples have been cached along the route. Instruments have detected simple organics, chlorinated benzene rings, and inference of nitrates as well. The Pahrump Hills rock has been tied to first layer of Mount Sharp. Caching is carried out by retaining piles of drilled powder closed within chambers. There are also about 75 (Sample Analysis at Mars) SAM instrument cups that can be put to use. Thus far the rover has acquired six drilled samples and numerous atmospheric samples. The drilling of a 7th solid sample is in progress. Curiosity is currently surveying the Murray formation, and is expected to take a few more months to get through it. The rover is now approaching ridges that contain much hematite, clay and sulfate. Methane measurements are ongoing; the sensors are detecting 0.7 ppb, by volume (background level). A ten-fold enhancement that lasted about 60 sols in Fall 2013 remains unexplained, and is thought to be due to either a weak local or strong distant source. Monitoring will continue. If another enhancement is detected, the sampling rate will be increased.

As to frost and brine predictions, which are of interest to Planetary Protection, no direct observations of either have been made to date. A few tenths of a micron-thick frost on the ground may have been possible during the fall and winter seasons (according to ground-based temperature measurements); there has been no evidence of frost on the ground or on the rover. Potential for brines do exist: minute amounts are considered possible at Mount Sharp based on meteorological measurements, but the brine formed would not qualify as a special region according to temperature and water activity (data from J. Rummel, *et al*). The site is too equatorial for carbon dioxide frost. Recurrent slope lineae (RSLs) are currently thought to be the best candidates for representing liquid flow, but as of yet, neither water nor salts have been identified. There is still no clear idea of what RSLs signify. The HiRise camera continues to search for RSLs in Gale Crater. Out of initially identified RSLs (none confirmed), only two in Curiosity's field area remain as candidates, pending additional imaging.

There was discussion on the methane chart. Dr. Spence asked about the date of the methane spike event, answered to be Fall 2013, and Dr. Lindberg asked if it was seasonal. Dr. Vasavada said that one

hypothesis was that the two spikes seen on the chart may be part of the same event as there are no measurements in between.

Earth Science Division Update

Dr. Michael Freilich, Director of the Earth Science Division (ESD) gave an overview of the Earth Science program, comprised of the themes of Flight, R&A, Applied Sciences, and Technology Development. Budget numbers are highly uncertain for Fiscal Year 2016 (FY16), as the House and Senate budget versions are quite different. Numbers stand at $1.974B from the Senate side and $1.450 from the House side. The FY16 House Appropriations mark-up is $1.683B, and the Senate's is $1.932B. Significant cuts to a previously healthy ESD budget are considered possible.

ESD's on-orbit constellation and planned missions continue to constitute the world's largest, most diverse Earth-observing satellite constellation. There are 18 on-orbit missions in operation. Recent changes include the termination of the Tropical Rainfall Measuring Mission (TRMM) in June 2015 (launched in 1997), and an Aquarius/Sac-D (sea surface salinity) bus failure. Despite the failure, the satellite nonetheless exceeded its three-year baseline mission. Soil Moisture Active Passive (SMAP), which launched in January 2015 suffered from a malfunction in its active radar system on July 7. While diagnosis efforts have not yet found a root cause, all other instruments are working well, and science operations continue. Without radar, the satellite's resolution diminishes from 10 km to 35 km. Dr. Lindberg asked if the SMAP radar has internal redundancies. Dr. Freilich answered that the radar does have some internal redundancy, but regarding the high power amplifier (HPA) and subsystems, the low voltage portion of it is not redundant. The problem appears likely to be a low voltage power supply to the high-power amplifier.

The ESD held a Senior Review and extended all the on-orbit constellation satellites. QuikSCAT did not apply to the Senior Review as RapidScat has since replaced it in terms of function. Earth Observing Mission-1 (EO-1), despite some orbiting changes, was also recommended for extension. The Orbiting Carbon Observatory-2 (OCO-2) launched in July 2014, and SMAP launched in January 2015. Missions in development include the Stratospheric Aerosol and Gas Experiment (SAGE) III, which will launch to the International Space Station (ISS) in a Dragon trunk on SpaceX 10. The Gravity Recovery and Climate Experiment Follow-on mission (GRACE-FO) is scheduled for launch in August 2017. The first Venture-class mission, the Cyclone Global Navigation Satellite System (CYGNSS), will launch in October 2016.

The ISS is being used for Earth observation where it makes sense, and will in the future host the Climate Absolute Radiance and Refractivity Observatory (CLARREO) Pathfinders (2019); the Land Information System (LIS) (2016); the ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS); and the Global Ecosystem Dynamics Investigation (GEDI) (2020). The Global Precipitation Measurement (GPM) mission, which includes 19 PIs from 13 countries, is providing direct measurements of rain, ice and snow. The international "A-train" of satellite, missions flying in close physical formation, work to provide multiple measurements within a few minutes of each other, encompassing a virtual observatory. Venture-class missions (EVs) continue to be solicited and selected on time and with full funding. The latest EV-Instrument-1 (EVI-1) is Tropospheric Emissions: Monitoring of Pollution (TEMPO), with instrument delivery in 2017. EV-Suborbital-1 (EVS-1) has completed five

suborbital missions. The EVS-2 solicitation has been released, and six projects have been selected, addressing measurement of carbon flux, melting of Greenland ice, and air quality. The EV-Mission-2 (EVM-2) draft solicitation is about to go out.

Flight programs supported by the FY16-20 budget runout include the Sentinel 6/Jason-CS mission. A U.S. agreement with Europe concerning the exchange of all Copernicus/Sentinel data was signed on July 9. ESD is continuing development of the Surface Water & Ocean Topography (SWOT) mission in preparation for a 2020 launch. The budget supports completion of the Total and Spectral Solar Irradiance-1 (TSIS-1) instrument and its flight on ISS, which is working toward a launch in 2017; NOAA funding for TSIS-1 has been transitioned to NASA funding. The Radiation Budget Instrument (RBI) to study Earth's radiation balance is due to be flown on the Joint Polar Satellite System-2 (JPSS-2) satellite (instrument delivery April 2019), but a stop work/cure notice was issued to the contractor in June due to sensitive procurement issues.

In 2014, NASA and USGS were asked to create a system design to continue the 43-year-old Landsat series. Landsat 7 (475 scenes/day) is expected to last to 2020. Landsat 8, launched in February 2013, is currently collecting 725 scenes/day (beyond its requirement of 400/day). While Landsat 8's fuel could last for 20 years, it does have a minor issue with its thermal infrared sensor, and is operating on redundant hardware. Sentinel 2, Europe's multi-spectral land imaging satellite (lacking thermal infrared, however) is a spacecraft that is complementary to Landsat. An agreement for open sharing of data has been established by the European Union, NASA, NOAA, USGS, and Department of State. Research investigations are also being solicited through ROSES to make an early investment in multi-instrument products for continuing the land-imaging program.

The President's 2016 budget supports a "3+1" approach to sustainable land imaging. This includes the rapid development of a Class D Thermal Infrared Free Flyer (TIR-FF) to launch no later than 2019 as a low-cost mitigation against early loss of Landsat 8's thermal infrared sensor. Landsat 9 is to be launched no later than 2023 (possibly 2021). A Land Imaging Technology and Systems Innovation program is under way to retire risk in next-generation missions; and a Landsat 10 launch is planned for approximately 2030. There are no current credible plans for a 2020 launch date for Landsat 9 (L9) in the FY15 appropriation. However, the FY16 Senate appropriations mark-up added $100M for L9 development for launch in 2020, but prohibits the launch of a TIR-FF prior to launch of L9. TIR-FF will not begin in FY16. L9 has been initiated with $60M in FY15 funds, and technology studies are under way.

Dr. Freilich presented science and outreach highlights, among which was a tweet sent out by President Obama, featuring the latest "blue marble" photo from the Deep Space Climate Observatory (DSCOVR) Earth Polychromatic Imaging Camera (EPIC) camera that takes 13 of these full-color images of the Earth per day. Quantitative data from the Argo satellite indicates that a recent hiatus in global warming trends seems to be caused by a decadal shift in Indo-Pacific heating (Science, July 2015), whereby heat has been observed to be pumping into ocean layers at the 100-300m level. Lastly, a paper on the state of the water cycle in the early 21st Century was recently published, using quantified numbers and uncertainties based on measurements from 25 satellites, representing a truly integrative analysis of Earth's systems.

Dr. Lindberg asked about the temporal alignment of the measurements of L8 and Sentinal 2A. Dr. Freilich responded that they are coordinated in a sense by not maximizing coverage, not flying behind each other. This allows them to be temporally merged. Dr. Peterson asked about the scattered light problem on L8, and Dr. Freilich responded that it can be fixed for future missions. It is a straightforward fix, but cannot be done once it is on orbit.

Pluto Close Approach by New Horizons

Dr. Bonnie Buratti presented science results from the recent New Horizons flyby of Pluto, as well as historical underpinnings. The small body was discovered in 1930 by Clyde Tombaugh, after unexplained perturbations in the orbits of Uranus and Neptune were found. Charon, one of Pluto's moons, was found in 1978. HST in July 2012 resolved all five satellites of Pluto. Dr. Douglas Duncan noted that Nix and Hydra were discovered by non-Ph.D.s, and Dr. Buratti stated that Tombaugh also was not a Ph.D. It is thought that Charon was created as the Earth's moon was created, by an impact of Pluto by another body. Asked about a rings system by Dr. Gaudi, Dr. Buratti stated that no evidence of rings has yet been found.

The mission objectives of New Horizons are to complete the inventory of the Solar System; map the surface of Pluto and Charon; characterize the atmosphere of Pluto; search for the atmosphere of Charon; and search for rings and other satellites around Pluto. In addition, New Horizons plans to investigate another Kuiper Belt object (KBO). The payload includes a visible and IR spectrometer, UV spectrometer, the Long Range Reconnaissance Imager (LORRI) to study geology and to search for moons and rings, and a student dust counter (SDC) instrument. Dr. Carle Pieters asked if instruments were scattered throughout the spacecraft and whether it could turn, for the best observations, and Dr. Buratti said this was the case. The spacecraft, during its gravity-assist maneuver at Jupiter, imaged a volcanic eruption on Io.

Images of Pluto as New Horizons approached it were shown, culminating in the closest views seen on July 14. The Committee enthusiastically made hypotheses on what was seen. Of particular interest was a heart-shaped region with higher brightness than the surrounding region. Dr. Buratti explained that such an area should not be there as it is in the dark equatorial region -- it is hypothesized to be frost. Some on the science team are speculating that the "heart" is the result of an impact that broke through to the ocean and released a flow. The bright area seems to be composed of nitrogen glaciers, and the appearance of some features on polygonal terrain suggests some volatile release. Also of interest were the mountains that are sublimating away. Dr. Pieters asked about a textured region and it was said to possibly be from flowing nitrogen ice. Dr. Pieters asked if there was tidal heating between Pluto and Charon and Dr. Buratti mentioned that as these are in circular orbits facing each other, there is none. Charon has been shown to be surprisingly crater-free, while also demonstrating a dark impact basin at its pole, and a large fault in the terminator region. Dr. Gaudi asked about what wavelengths were important in imaging the planet. Dr. Buratti mentioned that 0.5 to 0.9 in the visible and IR spectrum were useful, and that NIR Channel 4 was the end. Responding to a question by Dr. Pieters, Dr. Buratti noted that it has been found that the magnetosphere of Pluto has a tail, and Dr. Spence noted that this could be induced by the exosphere.

When asked how long it would take to receive the data on the Pluto system, Dr. Buratti responded that the bulk of it will arrive by November and will take 16 months to process. Also, an extended KBO mission is pending approval of extended mission status. The object is to be less than 100 km in size, similar to Phoebe. Dr. Buratti noted in her final comments that a large number of young people (post docs) and women powered the New Horizons project.

Public comment period
No comments were noted.

Discussion
Dr. Peterson addressed the next day's agenda, and suggested that the Committee give a brief report to Dr. Grunsfeld on preliminary items such as monitoring travel issues and requesting that travel rules to centers be clarified, and also mentioning that the Committee was working on goals and objectives regarding the Big Data Task Force. Dr. Spence raised the issue of bringing forward an HPS recommendation on the size of awards, and/or to reduce number of proposal pages from 15 to 10. Dr. Peterson felt it was not the Committee's place to manage how HPD does proposals, and suggesting putting off a finding, pending the AAAC report. APS brought forth no recommendations. Dr. Lindberg suggested a discussion of Dr. Freilich's report on the TIR Free Flyer. Dr. Peterson agreed, although citing the fact that the Free Flyer was not purely a science question, rather a question of Class B vs. Class C engineering expectations.

July 28, 2015
Dr. Peterson made opening remarks and commenced the day's meeting.

Heliophysics Division Update/Heliophysics Subcommittee report
Dr. Steve Clarke, the new HPD director, provided a summary of the four major Heliophysics programs: Solar Terrestrial Probes (STP), Living With a Star (LWS), Explorers, and Research, all of which provide data collection for space weather prediction purposes, and further understanding of the Sun-Earth connection. The STP mission Magnetospheric Multiscale (MMS) launched in March and is now going through commissioning. Operations will begin September 1. STP-5 is scheduled for 2023; HPD is currently looking at the trade space. In LWS, a suite of instruments for the Space Environment Testbed (SET) has been sent to the U.S. Air Force for an October 2016 launch on a Falcon 9 Heavy rocket. Solar Probe Plus (SPP) and the Solar Orbiter Collaboration (SOC) ESA collaboration continue in development. NASA is also working with ESA on the Explorer missions Ionospheric Connection (ICON) and Global-scale Observations of the Limb and Disk (GOLD), which constitute a Mission of Opportunity in 2020, and a Small Explorer (SMEX) mission in 2022, respectively; HPD is working on a draft AO, to be released as final in the Spring of 2016. In the Heliophysics Sounding Rocket Research program, a number of launches have been scheduled for August and September.

HPD has a total of 18 operating missions and 33 spacecraft, all of which form the Heliophysics System Observatory. Operating missions are green for the most part. Exceptions are Solar TErrestrial RElations Observatory (STEREO) B, which is out of contact after conjunction with the sun; STEREO A is in contact. An attempt will be made in November to raise STEREO B. NASA funding for the Cluster satellite, an ESA mission, ends in FY15. ESA will probably continue to fly it. Recent Heliophysics

science highlights include a finding on quasi-annual variations in solar storms; researchers feel that they are driven by changes in magnetic field bands. The Balloon Array for RBSP Relativistic Electron Losses (BARREL) mission, a balloon campaign in Antarctica held in conjunction with the Van Allen probes, was used to validate the theory of wave-particle interaction. The multi-agency Community Coordinated Modeling Center provided a simulation to PSD for space environment conditions, which will use Pluto flyby data to help validate the model. Time History of Events and Macroscale Interactions during Substorms (THEMIS) measurement revealed that breaking (ultralow frequency) waves from the Sun are able to influence cloud patterns on Earth.

Flight program status

SPP completed its mission critical design review (CDR) in March. A Black Brant motor cast was tested successfully. The Woods sounding rocket launched, but had to be terminated in flight as its componentry had been installed incorrectly. The payload was recovered. ICON is doing well. SOC's CDR was held in June, and was requested to hold a delta-CDR in January 2016 to ameliorate issues identified during CDR. SOC will continue to have monthly updates to stay on track for the delta-CDR. A Senior Review report was released in June, stating that all 15 missions under review have been approved for extension. In 2015, HPD was commended for noteworthy progress in the Strategic Objective Annual Review (SOAR) activity. Watch items and concerns include the delay of an Australian range Sounding Rocket campaign until 2017. HPD continues to evaluate funding and options for the Peregrine rocket, and STEREO A is expected to produce reduced science data through 2016.

The Koehler Rock On! Workshop, a sounding rocket experience for students, continues an ongoing program that engages both high school and college students. Milliner, an STMD experimental flight, was assessed: the Glenn payload performed nominally, while the Ames payload had a slight anomaly, but was judged to be successful overall. The PI is currently evaluating data. The Wallops Academy at the Wallops Island launch facility is teaching the basics of rocketry to teachers to support STEM education. Activity at the Wallops range include the removal of the 50K Launcher away from the Antares pad failure site, for safety reasons. Radar systems are also being upgraded, and Antares pad repair work is going well. An Orb-5 launch is on schedule from the Wallops site in November.

In HPD, the ROSES call is currently using a two-step process, which had been seen to work well in 2014 for Guest Investigator (GI) and Sounding Rocket calls. There is a three-page limit for Step 1 proposals. Metrics thus far include receipt of 767 Step-1 proposals. LWS just finished their review and has awarded 25/103 grants. The President's budget for 2016 for HPD is $651M, which meets requirements, and augments and implements the DRIVE initiative. The appropriations bills stand at $642M from the House side and 649.8M from the Senate; full budget resolution is pending. HPD, going forward, will work to assure a more balanced portfolio while assessing HPD resource needs, rebalancing staff load, and doing gap analysis from a Program Scientist standpoint. The division hopes to bring on more detailees and Intergovernmental Personnel Act employees (IPAs). HPD is also participating in the Office of Science and Technology (OSTP)-led Space Weather Operations, Research, and Mitigation (SWORM) task force, and is preparing to respond to actions coming from this. The division is also planning for more frequent, low-cost missions through Research and the Sounding Rocket program, as well as developing a Division Technology Investment Focus. HPD also intends to enhance interagency partnerships (NOAA, DOD,

ESA, ISRO) and engage the community by reaching out to key stakeholders with periodic meetings for idea-sharing and feedback.

Responding to a prior suggestion that HPD book-keep non-Heliophysics funds in JASD, Dr. Clarke noted that every SMD theme carries some bookkeeping projects, and that beginning in October 2016, NASA's directed Research and Technology (R&T) funds would be allocated across all four themes of SMD.

Dr. Spence welcomed Dr. Clarke, and asked what his perspective was on a balanced portfolio, as the current need is larger than the budget, coupled with extended missions that represent costs that could go to future missions. Dr. Clarke responded that HPD must consider how to achieve more objectives with lower cost missions, while noting that SPP has eaten up a lot of the budget. Launch cadence can be increased with lower cost missions. SWORM activities may be an opportunity for HPD, as it could potentially combine resources with NOAA for items such as space weather prediction. It is not known, however, if there will be funds to support SWORM actions.

Heliophysics Subcommittee

Dr. Neil Murphy presented a report from the Heliophysics Subcommittee (HPS), noting that the overarching theme of its most recent meeting was to welcome Dr. Clarke. In addition, HPS has acquired three new members. HPS commended HPD's SOAR 2015 accomplishment, as well as the six HPD CubeSats in development, noting that it is important that the science community recognize small satellites as important science missions that offer broadly valuable and interesting data sets. The HPS was also pleased to have all 15 operating missions continued per the Senior Review, to study a connected, complex system with distributed sensors. However, the HPS formed a consensus opinion that there has been an expansion of reviews in flight projects, and it would like to develop statistics on the number of formal reviews in terms of cost benefits. Some feel that the number of reviews is detracting from time spent on missions.

HPS heard four science presentations, one by Dr. Robert Leaman on the attempt to understand timescales of the solar cycle and what drives the solar dynamo, accompanied by data on asymmetries in the hemispheres and variations in Rossby waves. Dr. Stuart Bale contributed a presentation on ESA's proposed Turbulence Heating ObserveR (THOR). Dr. Ralph McNutt presented an inspiring talk on the Interstellar Probe mission as a new frontier in space, studying the interstellar medium. Dr. David Pierce presented results from NASA's airborne program and its opportunities for science.

Dr. Murphy noted that in the Heliophysics research, the two-step proposal process has helped address concerns about low selection rates, but HPS was concerned that people are proposing to both the GI and Sounding Rocket programs to do similar studies. The HPS suggests that HPD institute an exit survey about the quality of proposal reviews. HPS also recommended, for SC consideration, to either increase the size of grants, or reduce the size of proposals (from 15 to 10 or fewer pages). Dr. Pieters commented that proposal pressure was clearly a problem across SMD, and asked how proposal length could be altered to allow for rapid communication of the proposal's significance. Dr. Murphy felt that a statement of impact, a discussion of the value of the work, and establishment of credibility would be sufficient; JPL has a detailed six-page template for proposals, which may provide a solution.

HPS brought forward a previous finding, which states that NASA should offer uses of fueled payload-adapter-fittings (PAFs) as part of their launch services, or enable the use of such capabilities by the proposers, outside the cost cap, to enable a wider range of orbits at reduced cost to NASA. HPS deferred a few topics for future discussion, such as lack of HPD staffing, and the number of flight reviews.

Science highlights included a THEMIS mission paper on the "wavy" magnetopause, which is considered significant because the frequent occurrence of Kelvin-Helmholtz waves has implications for plasma entry into the magnetosphere of Earth. A "monster" inverse first ionization potential (FIP) effect was observed in the Sun, based on data from Hinode. A HYPERION code simulation of the coronal loop was compared with Hinode data, providing some agreement on why the sun is hotter on the outside than the inside, based on the behaviors of compressible plasma, radiation transport, and thermal conduction. A movie of gravity waves (modeled) in the mesopause region that have propagated into the upper atmosphere was presented; GOLD and ICON will be viewing these regions remotely, in the ultraviolet spectrum. Aeronomy of Ice in the Mesosphere (AIM) nitric oxide (NO) data is being used to validate models of atmospheric coupling, demonstrating space weather effects on atmospheric dynamics and increasing the fidelity of modeling. Dr. Peterson noted HPS did not require SC concurrence on its grants recommendation, as the issue is being taken up by the previously mentioned AAAC task force.

Dr. Peterson returned to the issue of the number and nature of individual flight projects reviews. Dr. Green noted that projects awarded under Class D are having oversight at a Class B or A level. There sometimes is a pre-review a week before the real review that requires personnel to travel and a short report. Dr. Lindberg suggested that facts be collected, such as the requirements of a D project and what is happening on those projects.

Planetary Protection Officer Update/Subcommittee Report

Dr. Catharine Conley, Planetary Protection Officer (PPO), reported on the status of the office, providing a background on the reasoning behind implementing planetary protection, i.e. to protect the science goals of space exploration, and to assure the safety of human explorers and the integrity of terrestrial life. NASA Policy Document NPD 8020.7G identifies the responsibilities of the PPO, while NASA obtains policy guidance from the National Research Council (NRC) Space Studies Board (SSB) and from the NAC PPS, and from the United Nations (UN) Committee on Space Research (COSPAR). In May 2014, NASA Policy Instruction (NPI) 8020.7 was released, containing policy guidelines for planetary protection for human extraterrestrial missions. Requirements established for planetary protection for robotics missions are contained in NPR 8020.12D.

The Planetary Protection Subcommittee (PPS) provides expert advice to NASA. November 2012 recommendations from PPS included a concern about MSL Lessons Learned being incorporated into future Mars missions – the NASA response is ongoing. In April 2013, PPS recommended that the PPO be included early in mission design and work, and that is in work. In November 2014, PPS recommended improving communication between the MSL team and the PPO in response to novel findings concerning the prevalence of water at Gale Crater and the necessity of having the rover avoid potential special regions, and that is in work.

Dr. Conley reported being pleased by the improved communication with InSight, Mars 2020 and HEOMD, as well as with additional support and an increase in planetary protection awareness across the agency. Concerns with the PPO reporting line placement and consistency with responsibility across directorate are still in work. The PPS is also working to support meetings with planetary protection counterparts in ESA; PPS Chair Lindberg was able to attend a spring meeting of the ESA counterpart in planetary protection. Given the increasing number of missions to Mars, planetary protection is becoming a more visible issue. Ongoing actions for the PPO include recommended responses to MSL Lessons Learned; the hiring of new staff; expanding training options; coordinating with HEOMD; developing an Operating Plan; engaging interfaces with the Federal Aviation Administration (FAA) on launch services; and the creation of an internal coordination group to provide a forum for Office of General Counsel, legislative affairs, etc.

Dr. Lindberg is talking to Dr. Luhmann (PSS Chair) about a PPS/PSS joint meeting in about a year that had grown out of the SC/Human Exploration and Operations Committee joint meeting productivity.

PPS

Dr. Lindberg, Chair of the PPS, reported on the June meeting. The subcommittee welcomed six new members, for a total of 12 voting members, plus representatives from five international space agencies, and three U.S. government agencies. PPS plans to invite India and the United Arab Emirates (UAE) to participate. The most recent meeting received updates on a Planetary Protection Strategic Knowledge Gap (SKG) workshop, a NASA communications campaign, a report on an SSB meeting of experts on Terrestrial Organic Contamination, the Mars 2020 and Juno missions, ESA and COSPAR planetary protection efforts, the Mars InSight mission and the MarCO (Mars Cube One) CubeSats riding along with it, and requirements for sample caching on future Mars sample return missions. Top issues on the agenda include a review of ongoing and planned missions for planetary protection categorization, a recommendation for the categorization of the Mars 2020 mission, concerns about unanticipated findings from MSL surface operations, an SSB Meeting of Experts report minority opinion, and planning for a PPS/ESA Planetary Protection Working Group meeting in Madrid in October 2015. Topics for the future include a review of the International Mars Architecture for the Return of Samples; following latest science discoveries from Curiosity; a briefing on awarded 2014 ROSES studies on planetary protection technologies; a joint meeting with the Curation and Analysis Planning Team for Extraterrestrial Materials (CAPTEM); consideration of a joint meeting between the Planetary Science Subcommittee (PSS) and PPS; the need for regulatory bodies to monitor planetary protection compliance of non-state actors; and spacecraft cleanliness requirements that will be needed for contact with special regions on Mars.

Recommendations to be brought forward to the Science Committee

PPS recommends that the Mars 2020 mission be given a Category V, restricted Earth return classification. Dr. Peterson asked for more information on the distinctions between categories. Dr. Lindberg answered that the classification rests on the assumption that the Mars 2020 mission is caching samples that may someday return to Earth, and which may contain extant or ancient, extinct life. NASA policy also requires a category IVb classification for the outbound legs of sample return missions to avoid forward contamination of Mars, Europa and Enceladus. Dr. Peterson felt the SC did not need to get involved in

categorizations, and Dr. Robinson asked why this would go to the NAC as a recommendation. Dr. Lindberg noted that because the SMD Associate Administrator (AA) is responsible for planetary protection, he felt the SC should bring the recommendation to the AA as a procedural matter, as per Federal guidelines governing planetary protection. He also noted that NASA provides information and documentation to support decision-makers in returning a Mars sample.

Dr. Lindberg brought forth a second PPS recommendation from its June 2015 meeting, in which it recommends that NASA develop a contingency plan to address planetary protection issues as they arise during MSL surface operations. PPS also recommends that NASA convene a Gale Crater "trailblazer" workshop to address the development of a contingency plan to address scientific discoveries made by the MSL team. Dr. Lindberg felt that NASA should think about adopting this approach in all forward-going missions, in part because science results obtained during missions may lead to identification of a special region. As an alternative to *a priori* guidelines, each mission should develop a contingency plan to enable the science team, operations team and PPO to discuss unanticipated discoveries.

Open recommendations from PPS include a tabled recommendation to improve MSL communications with the PPO, NASA's internal review of proposed licenses for private space actors (which is not resolved but getting deserved attention), and tentative plans to reach out to other international actors such as China or Israel.

Astrophysics Division/Astrophysics Subcommittee

Dr. Paul Hertz, Director of the Astrophysics Division (APD), discussed the status of the division and its response to the Decadal Survey, aided by an Implementation Plan that was updated in 2014. In addition, the division's Astrophysics Roadmap lays out science that could be accomplished over 30 years. In general, APD has a steady budget of about $1.3B through the 5-year planning horizon, including funds for maintaining progress on the James Webb Space Telescope (JWST). The Wide-Field Infrared Survey Telescope (WFIRST) is in its pre-formulation phase, while SOFIA is operating with a reduced FY15 budget. APD is planning for its next Senior Review in 2016. A Mid-Decade Review for Astrophysics is under way, chaired by Jackie Hewitt of MIT, and preparations are now being made for the next Decadal Survey. Missions in development for Astrophysics include ESA's Laser Interferometer Space Antenna (LISA) Pathfinder that is scheduled for a mid-November to mid-December launch. ASTRO-H, a Japanese space agency (JAXA) x-ray observatory, is now in environmental testing, with launch date in late 2015 or early 2016. The Neutron-star Interior Composition Explorer (NICER), an Explorer mission of opportunity for the study of neutron stars, is scheduled to launch to ISS in August 2016. Transiting Exoplanet Survey Satellite (TESS), a medium-class Explorer (MIDEX) mission, the next exoplanet mission and it will discover the nearest and brightest transiting exoplanets, moves to CDR in the first week in August, and is scheduled for launch in 2017. JWST is on track to launch in 2018, and it will be capable of performing spectroscopic follow-up off TESS-discovered exoplanets. NASA is also supplying sensor chip systems for ESA's Euclid mission.

JWST has finished vibration testing of all Integrated Science Instrument Module (ISIM) instruments. The telescope backplane is fully assembled and will be shipped to Goddard Space Flight Center (GSFC) next month, where the mirrors will be installed into the backplane over the next year. The JWST cryocooler

compressor assembly was shipped to JPL in July. Optical Ground Support Equipment Test #1 in the large Chamber A at JSC is complete, with Test #2 scheduled in the Fall. JWST still holds nine months of funded schedule reserve on the critical path.

NASA is addressing Decadal Survey recommendations, including working on pre-formulation for WFIRST/Astrophysics Focused Telescope Assets (AFTA), partnering with ESA on its Athena mission to attain Decadal Survey science enabled by an international X-ray observatory, and increasing the cadence of AOs in the Explorer line. The WFIRST Science Definition Team (SDT) completed its report in March 2015, and funding was made available for preparatory science studies. APD released a solicitation for a WFIRST formulation science working group to replace the SDT, and a WFIRST Request for Information (RFI) for industry engagement was released on July 7. A technology maturation plan for WFIRST was developed 18 months ago, which identified a number of milestones for both the widefield instrument detectors and the coronagraph instrument to help the mission get to Technology Readiness Level (TRL)-5 before KDP-A, to avoid schedule and cost growth later on. Thus far WFIRST has met all technology milestones ahead of schedule.

The 2015 budget stands at $685M for Astrophysics, and $645M for JWST. The President's 2016 Budget Request includes funding to maintain progress toward the planned launch for JWST and supports all current programs and projects including HST, which may operate concurrently with JWST if possible. The budget and runout are "flattish." The FY16 Congressional markups are partially earmarked in various areas, such that APD might be challenged to find $20-35M from the rest of Astrophysics. The markups contain specific language warning against a JWST overrun, as well as direction to include a coronagraph for WFIRST, and to accelerate the exoplanet program. There is conflicting language on SOFIA. The Senate has called for an increase in Explorer Announcement of Opportunity (AO) frequency to every 3 years, with an eventual goal of every 2 years.

APD is preparing for next Decadal Survey by studying 3-4 large mission concept studies as input, to include a science case, technology assessments, design reference mission with strawman payload, and independent cost assessments. The Program Analysis Groups (PAGs) have been asked for their input and community workshops are being organized. The four suggested missions are: Far IR Surveyor; Habitable Exoplanet Imaging Mission; UV/OPT/IR Surveyor; and X-Ray Surveyor. APD is also starting a discussion on medium-sized missions, to close out by the end of the year. The Survey may recommend a competitive New Frontiers-style Probe Program. Asked about the risk buy-down on WFIRST, Dr. Hertz reported that APD has spent $50M per year on pre-formulation, for a total of more than $100M altogether, with at least half the funding going to technology development.

Astrophysics Subcommittee (APS)

Dr. Scott Gaudi, Chair of the Astrophysics Subcommittee (APS), presented a briefing on its most recent meeting. APS has welcomed Dr. Paul Scowen as a new member, with two members having rotating off. Science events of note include observations by Kepler in its K2 mode (two reaction wheels), which was able to observe Neptune during K2 campaign 3, acquiring 100K images over 80 days and getting extremely precise photometry. Such imagery allows astroseismology assessments of the planet, and measurement of internal structure. An HST observation of galactic cluster (GC) 47 Tucanae captured an

instance of stellar exodus and mass segregation in action, revealing young white dwarfs in the cluster. Candidates for rocky Earths in the habitable zone have been identified: Kepler-138b, at half the size of Earth, and with less mass than Mars, and Kepler 452B, which is 60% larger than Earth (1.6x the radius of Earth, not sure if its rocky) and is orbiting a star almost exactly like Sun. Other candidates remain to be confirmed.

APS heard a summary from its PI of TESS, an all-sky survey that images a stripe from ecliptic pole to equator, which in two years of operation will cover almost the entire sky. TESS's objective is to find 1000 planets smaller than Neptune, which will then provide the best targets for JWST observations. TESS is on track for launch in 2017. The subcommittee also heard about ESA's Gravitational Observatory Advisory Team (GOAT), which is evaluating a gravitational wave observatory that is envisioned for launch in 2034. APS members also heard a summary of the Inclusive Astronomy Meeting, held at Vanderbilt University that addressed the issue of underrepresented minorities in astrophysics, with the aim to understand the cause and address the problem. NSF has a program that supports efforts to ease the transition of individuals across critical academic junctures (the Partnerships in Astronomy & Astrophysics Research and Education [PAARE] program), and that this program was inspired by a former NASA program, the Minority University College Education and Research Partnership Initiative (MUCERPI). However, MUCERPI was renamed the Minority University Research and Education Program (MUREP) over a decade ago, and its awards now cover a much broader demographic than the original MUCERPI program, and thus is less effective at addressing the transition issue. The APS concluded that before making any recommendations on this issue, they needed more historical data about the NASA MUREP program and the scope of its awards over the past decade.

APS also carried out the Government Performance and Results Modernization Act (GPRMA) activity on APD and concluded that measurements of progress toward all APD science goals are Green.

Dr. Gaudi reviewed the charge to the PAGs on Decadal Survey mission concept studies; the report is due in October 2015. The missions under study are to follow JWST and WFIRST. The report is to provide no detailed architecture, no advocacy or advice, no prioritization, and no attempt to populate the Science and Technology Definition Teams (STDTs). The ultimate goal is to maximize the potential of all the missions. The Far-IR Surveyor group met at JPL, and discussed a monolithic design. The Habitable Exoplanet Imaging Mission has been envisioned as encompassing a less-than-8m telescope, monolithic, possibly segmented mirror, including a coronagraph or starshade, able to detect a 30th magnitude planet, in a L2 or Earth-trailing orbit, and UV-capable. The "LUVOIR" (IR/optical/UV) Surveyor is characterized as segmented with an obscured primary, likely coronagraph, and camera to include optical and near IR for planet characterization. The X-ray Surveyor is to include a high-resolution spectrometer. The timeline thus far has included many meetings with much discussion on how to coordinate efforts. The PAGs will have five more meetings before the delivery of the report in October. The Cosmic Origins and Exoplanet PAGs (COPAG, ExoPAG) websites contain information on meetings. There will be joint executive summaries for the separate reports, and thus far there seems to be convergence on the four suggested missions. There have been many discussions about Probes (roughly $1B-class missions), but there is no consensus yet. However there is broad community interest in Probe missions, which will be reflected in the executive summary.

As time was running out, questions and answers for the Astrophysics session were held until after the discussion with the SMD AA.

Discussion with SMD AA

The committee held a question-and-answer session with the SMD AA. Dr. Grunsfeld reported that he had just returned from a hearing with the House Science, Space and Technology Committee, one of NASA's authorization committees, where he had held a great scientific discussion with participants including Dr. Alan Stern of Southwest Research Institute (SWRI) and Dr. Bobby Braun of Georgia Tech who is a former NASA Chief Technologist. Congress was anxious to hear about the latest science results from NASA, and the same committee will hold an astrobiology meeting next month [the hearing was subsequently rescheduled by the Committee for September 2015]. The question of whether we are alone in the universe is becoming a tangible one. Privately funded searchers are also interested, thus this may be a time of convergence of efforts between public and private sectors. Dr. Grunsfeld was encouraged by the well-attended meeting. He felt there was a low probability of a government shutdown, but some probability of a Continuing Resolution (CR). Few NASA programs would be affected even if the appropriations lagged. He thanked Dr. Peterson for stepping up to the position of Chair and the SC for their participation, especially appreciating the SC's brain trust for input to strategic planning.

Asked about the biggest challenges facing SMD, Dr. Grunsfeld responded that overall, the directorate is doing reasonably well. On the travel issue, while he did not see great strictures at Headquarters, he was still getting feedback that travel approval is still too difficult. He thought that continued attention to the matter is important, and urged SC members to keep communicating to the community that folks need to push on their center connections to assure that requests be turned in on a timely basis. Another attendant issue is IT security; there will be increasing restriction in this area. Dr. Peterson informed Dr. Grunsfeld of the SC's stance on the Big Data Task Force; and also brought to his attention the perception that the number and nature of instrument reviews have mushroomed, and that the Committee was now in the process of quantifying the problem. Dr. Peterson requested some clarification from Headquarters on a PI's authority for determining review structures and asking for waivers. Dr. Grunsfeld asked for more data on this issue from PSD Director Dr. Green.

Dr. Lindberg raised concerns about the Thermal Infrared Free Flyer (TIR-FF) and guidance from the legislative branch on the timing of the launch. Dr. Grunsfeld noted that he had initially thought TIR-FF was a clever strategy and a robust technology investment, but felt that the time for dialogue is over. The USGS and Department of Interior have refined their analyses, based on the behavior of a quiet sun, which is more encouraging about the chances that Landsat 7 will make it to the 2020-21 timeframe. He was not sure a NAC recommendation would make a difference to the situation. He felt that NASA has successfully argued for new technology investment to support future Landsat launches. Dr. Grunsfeld reported being comfortable with the current state of affairs. Dr. Robinson asked if Dr. Grunsfeld had any thoughts about the Big Data Task Force. He replied that no specific needs came to mind but that he was willing to work on a needs statement iteratively, with an emphasis on IT security and accessibility. Dr. Hertz commented that big data for Astrophysics is more about interoperability between data structures, while for other communities, it is about querying large unstructured databases.

In response to a question, Dr. Grunsfeld felt that the SC would do well to hold discussions with HEOMD on humans assembling large telescopes in space, human/robotics interface, and utilizing SLS, as well as to work with the PPO on the implications of humans bringing Earth life to Mars. Dr. Conley noted that big data capabilities would be useful looking at changes in an ecosystem over time. Dr. Mainzer raised the issue of proposal pressure, award sizes, and streamlining processes. Dr. Grunsfeld stated that he was starting to get a picture of the problem, and felt that one option would be to write shorter proposals, even with its pros and cons. In general, almost all the proposals are very good; one could almost roll the dice and get a balanced program. Dr. Hertz warned that while larger award sizes can be provided, they come with a cost trade in terms of program balance. While he felt one approach could be slowing down the Explorer and technology programs to put more money into research, it was not how APD interpreted the Decadal Survey. The money has to come from somewhere. Dr. Peterson and Dr. Hertz concurred that the issue was something the Mid-Decadal Review could address.

Asked for his thoughts on the New Horizons mission, Dr. Grunsfeld replied that it was interesting to note that roughly speaking, Pluto is at 50°K, has winter-summer asymmetry, and will be able to provide more data about the Solar System; the other notable thought is that the public is genuinely and deeply interested in what NASA is doing. Social networking has been valuable in disseminating information. High-definition imagery will resonate more with the public, and perhaps spark more interest in STEM education. He urged that all scientists must keep public engagement on their radar screens, but deferred the discussion to a more formal treatment at the next meeting, as the education effort is in the middle of a Cooperative Agreement selection that is competition-sensitive at the moment. Dr. Duncan noted that he had seen statistics on the dearth of minority Ph.D.s in the sciences, and called for an effort to help minority children identify with the space program. Dr. Grunsfeld felt the issue had to do with having an informed populace and making good decisions in life. In the Office of Education, NASA has targeted programs for underserved communities. It is also a cultural issue in the U.S. Twenty years ago, the same statement could have been made about women. There is a phase lag that will be corrected over time. Dr. Gaudi added that the Graduate Record Examination (GRE) selects against underrepresented minorities, and it's been shown that GREs are not good predictors of success in grad school. Dr. Duncan thought that the business community was beginning to recognize that diverse groups function better. Dr. Grunsfeld felt that the millennial generation will solve this problem, and that NASA should encourage its progress.

Discussion

Returning to questions and answers on the Astrophysics session, the SC discussed the implications of the PAG reports on new Astrophysics missions and the charge from the APD Director. Dr. Peterson felt the report was exoplanet-heavy. Dr. Pieters expressed an interest in the new New Frontiers-like Probe class, and asked if these $1B missions could be competed. Dr. Hertz offered, as examples of Probe-class missions, Kepler, Fermi and Spitzer, all costing between $500M and $1B. The more recently studied Exo-S (exoplanet-starshade) and Exo-C (exoplanet-coronagraph) mission concepts cost about $1B, according to independent cost assessments. He added that there is substantial funding available over the years for strategic missions, but that the tradeoff is always cost vs. cadence. Does the community want one $5B mission or five $1B missions? The last Astrophysics Decadal Survey favored large missions only, and Dr. Hertz would have preferred a more balanced portfolio with some medium-size missions recommended.

Dr. Gaudi commented that he had observed, in response to Probe class missions, that there was no community consensus, but rather high interest, some for specific missions, some for just a Probe-class line. It is clear that people feel interesting science can be done at Probe-class levels. Dr. Pieters felt that there must be a more realistic way of discussing strategic missions vs. Probes. Dr. Gaudi noted that in the previous Decadal Survey, people have been presenting some Probe concepts that when costed, proved to be far more expensive than $1B.

Dr. Pieters suggested a deeper discussion regarding education and communication and how it's structured within SMD. Dr. Hertz observed that while education is bookkept in APD, it belongs to SMD. Its placement is irrelevant - the money will be managed across SMD. Communication, however, still falls within each individual mission, program and Division. Funding for education is this year $42M. Ms. Denning noted that the SC has an education briefing scheduled for its Fall meeting.

The committee wrapped up discussion time for Day 2 of the meeting. Dr. Green agreed to collect data on the issue of review pressure on operating missions, and took an action to prepare a report for November. Dr. Robinson sent a 2006 PowerPoint (Ledbetter) presentation outlining guidelines for class C and D reviews to Ms. Denning for future reference. Dr. Peterson suggested that members reach out to centers and ask what the standard review practice is. Dr. Murphy noted that HPS is working on this issue as well.

July 29, 2015

Discussion, Findings and Recommendations

Members reconvened to discuss four recommendations to bring forward to the NAC: PPS recommendations on the categorization of Mars 2020 as well as a contingency action plan for planetary protection, an HPS recommendation on proposal changes, and an HPS recommendation on PAFs.

The first PPS recommendation on Mars 2020 categorization will go directly to the SMD AA, after presentation to the NAC. The SC approved this recommendation by acclamation.

The second recommendation for developing a response process for current and future surface operations on Mars, Dr. Lindberg characterized the second PPS recommendation as developing an agreement among PPO, science and operations teams, as a way to move forward in the face of unanticipated science results, in contrast to having an *a priori* list of "stop" items. The SC approved this recommendation by acclamation.

In response to the HPS recommendation to decrease the length of proposals and increase the size of grants, Dr. Peterson felt that it didn't need to be kicked up to the NAC. Dr. Murphy agreed, but felt the recommendation should apply to all sub-disciplines. Dr. Peterson suggested that the SC respond to HPS, and couch it as an operational issue, to be guided by outcome of AAAC report on the subject. Dr. Murphy added that there is a tentativeness in HPS about these questions, and thought that the AAAC report will have some analysis that HPS can fold into its thinking. Dr. Peterson commented that the current situation disproportionately affects younger people, as it is much harder to get an initial grant without prior recognition. Dr. Peterson agreed to inform the NAC that the issue is both ongoing and applicable to SMD

at large, and will be revisited after the AAAC report is released. Dr. Pieters asked that the subcommittees provide their individual feedback about the AAAC report and revisit the subject at the next SC meeting. Dr. Peterson concurred.

In response to the HPS recommendation on the utilization of PAFs, the committee discussed the definition of PAFs, which were described as next-generation ESPA (Evolved Expendable Launch Vehicle (EELV) Secondary Payload Adapter) rings. PAFs contain a propulsion system that can propel the payload to a different orbit and are potentially very useful for the Explorer program, enabling constellations of spacecraft within Explorer cost caps, and getting more science per dollar out of the Explorers program. Dr. Pieters commented that many Principal Investigators (PIs) would be likely to be uncomfortable with a secondary mission attached to a primary payload. Dr. Murphy explained that PAFs are commercial capabilities, wherein the primary can be a commercial geocommunications satellite. Dr. Gregg Vane of NASA JPL noted that the Mars InSight mission would be carrying two CubeSats, which are undergoing the same review process as the primary mission. Dr. Mainzer felt that co-manifests were always a tricky proposition. Dr. Mainzer suggested the SC merely recommend that NASA consider adding PAFs to their list of approved commercial launch services, and pointed out that the use of microsatellites is in fact being considered in the next Decadal Surveys. The SC concurred that the recommendation be carried forward to the NAC.

Drs. Peterson, Lindberg and Robinson took an action to follow up on the Big Data Task Force TOR goals and objectives products. Dr. Green took an action to compile real data on class C/D instrument reviews. Dr. Duncan encouraged SC members to think about SMD's role in minority access issue, in that it was important for NASA to be proactive to protect the future NASA work force. Dr. Murphy mentioned a UT Austin program for integrating undergrad students into PI research, which has documented a significant retention of minority students. Dr. Mainzer mentioned that NASA's Harriet Jenkins pre-doctoral fellowship has been systematically defunded, but that the infrastructure still exists. Drs. Pieters, Duncan and Mainzer agreed to prepare a recommendation on this item for the next meeting.

Dr. Peterson adjourned the meeting at 9:37 am.

Appendix A
Attendees

NAC Science Committee Members
Bradley Peterson, Ohio State University, ***Chair, Science Committee***
Susan Avery, Woods Hole Oceanographic Institution *(via telecon)*
Jill Dahlburg, Naval Research Laboratory *(designee) (via telecon)*
Douglas Duncan, University of Colorado, Boulder
Scott Gaudi, Ohio State University, Chair, Astrophysics Subcommittee
James Green, University of Colorado, Boulder
Robert Lindberg, Jr., University of Virginia, Chair, Planetary Protection Subcommittee
Amy Mainzer, Jet Propulsion Laboratory *(designee)*
Neil Murphy, Jet Propulsion Laboratory *(designee)*
Carlé Pieters, Brown University
Mark Robinson, Arizona State University
Harlan Spence, University of New Hampshire
Elaine Denning, NASA Headquarters, ***Executive Secretary, Science Committee***

NASA In-Person Attendees
Bonnie Buratti, NASA JPL
Louis Friedman, NASA JPL
Dave Gallagher, NASA JPL
Dan McCleese, NASA JPL
Glenn Sellar, NASA JPL
Ashwin Vasavada, NASA JPL
Gregg Vane, NASA JPL

Non-NASA In-Person Attendees
Larry Richardson, ULA
Steve Squyres, Cornell, ***NAC Chair***
Ana Wilson, Zantech IT
Joan Zimmermann, Zantech IT

Webex/Telecon attendees
Jassim Al-Saadi, NASA HQ
Max Bernstein, NASA HQ
Jason Burgess, NASA JPL
Felicia Chou, NASA HQ
Steve Clarke, NASA HQ
Steven Clark, Space Flight Now
Steve Cole, NASA HQ
Catharine Conley, NASA HQ
James Dean, Florida Today
Lamont DiBiasi, SWRI
John Dyster, Orbital Sciences
T. Jens Feeley, NASA HQ
Michael Freilich, NASA HQ
James Green, NASA HQ
Nicole Grudger, NASA HQ

John Grunsfeld, NASA HQ
Paul Hertz, NASA HQ
Robert Holland, NASA JPL
David Leisawitz, NASA HQ
Dan Leone, Space News
James Lochner, USRA
Paul Mahaffy, NASA GSFC
Richard Mattingly, NASA JPL
Doreen Neil, NASA HQ
Jeff Newmark, NASA HQ
Tracey Osborne, NASA OCFO
Christa Peters-Lidard, NASA GSFC
John Rummel, ECU
David Seidel, NASA JPL
Eric Smith, NASA HQ
Erin Smith, NASA HQ
Marcia Smith, Space Policy Online
George Tahu, NASA HQ
Nicholas White, NASA HQ
Alexandra Witze, Nature

Appendix B
NAC Science Committee Membership

Dr. Bradley Peterson (Chair)
Ohio State University

Dr. Susan Avery
Woods Hole Oceanographic Institution

Dr. Douglas Duncan
University of Colorado at Boulder

Dr. Bernard Scott Gaudi
The Ohio State University

Dr. James Green
University of Colorado

Dr. Robert Kirshner
Harvard University

Dr. Robert Lindberg
University of Virginia

Dr. Janet Luhmann
University of California, Berkeley

Dr. Carlé Pieters
Brown University

Dr. Mark S. Robinson
Arizona State University

Dr. Steve Running
University of Montana

Dr. Harlan Spence
University of New Hampshire

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

Ms. Elaine Denning (Executive Secretary)
NASA Headquarters

Appendix C
Presentations

1. Research and Analysis Two-step Proposal Data; *Max Bernstein*
2. Ad Hoc Big Data Task Force; *Erin Smith*
3. "The Surprising Moon!"; *Mark Robinson*
4. Planetary Science Division Update; *James Green*
5. Curiosity Update; *Ashwin Vasavada*
6. Earth Science Division Update; *Michael Freilich*
7. New Horizons: First Science Results; *Bonnie Buratti*
8. Heliophysics Division Update; *Steven Clarke*
9. Heliophysics Subcommittee Update; *Jill Dahlburg/Neil Murphy*
10. Planetary Protection Officer Update; *Catharine Conley*
11. Planetary Protection Subcommittee; *Robert Lindberg*
12. Astrophysics Division Update; *Paul Hertz*
13. Astrophysics Subcommittee Update; *Scott Gaudi*

Appendix D

Agenda

NASA Advisory Council
Science Committee

July 27-29, 2015
Jet Propulsion Laboratory
Special Events Room (SER), Building 167
4800 Oak Grove Drive
Pasadena, CA 91011

Agenda

(Pacific Daylight Savings Time)

Monday, July 27

9:30 – 9:45	Opening Remarks / Introduction of Members	Ms. Elaine Denning Dr. Bradley Peterson
9:45 – 10:30	R&A Two Step Proposal Data	Dr. Max Bernstein
10:30 – 10:40	***BREAK***	
10:40 – 11:00	Ad Hoc Big Data Task Force	Dr. Erin Smith
11:00 – 11:50	Discussion	
11:50 – 1:00	***LUNCH*** – Member Research Presentation "The Surprising Moon!"	Dr. Mark Robinson
1:00 – 2:00	PSD Division Update Curiosity Update	Dr. James Green Dr. Ashwin Vasavada
2:00 – 3:00	ESD Division Update	Dr. Michael Freilich
3:00 – 3:10	***BREAK***	
3:10 – 3:55	Pluto Close Approach by New Horizons	Dr. Bonnie Buratti
3:55 – 4:00	Public Comment	
4:00 – 5:00	Discussion	
5:00	***ADJOURN***	

Tuesday, July 28

8:00	Re-Open Meeting	Ms. Elaine Denning Dr. Bradley Peterson
8:05 – 9:00	HPD Division Update Heliophysics Subcommittee Report	Mr. Steve Clarke Dr. Jill Dahlburg / Dr. Neil Murphy
9:00 – 9:55	Planetary Protection Officer Update Planetary Protection Subcommittee Report	Dr. Cassie Conley Dr. Robert Lindberg
9:55 – 10:50	APD Division Update Astrophysics Subcommittee Report	Dr. Paul Hertz Dr. Scott Gaudi
10:50 – 11:00	***BREAK***	
11:00 – 12:00	Discussion with SMD Associate Administrator	Dr. John M. Grunsfeld
12:00 – 12:45	***LUNCH***	
12:45 – 1:00	Wrap-Up Discussion for Day 2	
1:00	***ADJOURN***	

Wednesday, July 29

8:00 – 9:45	Discussion, Findings and Recommendations
9:45	***ADJOURN SCIENCE COMMITTEE MEETING***

Dial-In and WebEx Information

For entire meeting July 27-July 29, 2015

Dial-In (audio): Dial the USA toll-free conference call number 1-800-988-9663 or toll number 1-517-308-9483 and then enter the numeric participant passcode: 8015. You must use a touch-tone phone to participate in this meeting.

WebEx (view presentations online): The web link is https://nasa.webex.com, the meeting number is 991 957 517, and the password is Science@July2015.

**** All times are Pacific Daylight Time ****