

# NASA ADVISORY COUNCIL

## SCIENCE COMMITTEE

April 18-19, 2013

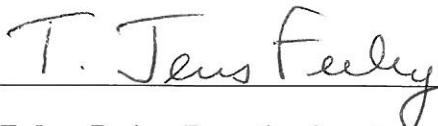
NASA Headquarters  
Washington, D.C.

### MEETING REPORT



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Wesley T. Huntress, Chair



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T. Jens Feeley, Executive Secretary

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***Prepared by Joan M. Zimmermann  
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April 18, 2013

Welcome and Introduction

Dr. Wesley Huntress, Chair for the NASA Advisory Council (NAC) Science Committee (SC) opened the meeting, and welcomed members, noting the addition of new member Dr. Carlé Pieters, member-at-large for planetary science. He also noted the absence of SC member Dr. Noel Hinners, and the presence of Dr. Eugene Levy via telecom. Members introduced themselves around the table.

Dr. Huntress addressed the primary items on the agenda: a new asteroid-capture initiative in the Human Exploration and Operations Mission Directorate (HEOMD), in which science will play only a supporting role in the finding potential target asteroids for retrieval. The second item is the Fiscal Year 2014 (FY14) budget proposal. The FY13 budget is still wrapped up in sequestration, and there are complications arising from the Continuing Resolution (CR) that will not be sorted out until the release of the NASA FY13 Operating Plan (OP). He noted that Congress did not agree with the proposed reduction to the Planetary Science Division (PSD) and restored a large part of it in the FY13 appropriations act. A glaring feature of the FY14 budget request is the continued reduction to planetary science of nearly \$300M, which is not consistent with prior Congressional action on the FY13 appropriations. However, there is good news in the budget for the Science Mission Directorate (SMD); JWST remains a priority, the budget for the Earth Science Division (ESD) is increasing in a flat era, and the Heliophysics Division (HPD) has been done no harm. The gorilla yet lurking is the potential for targeted reductions in NASA, as opposed to the sweeping reductions of the current sequestration. Executive Secretary Dr. T. Jens Feeley made some logistical announcements.

Ethics Briefing

Mr. Adam Greenstone led the requisite annual ethics training for the Committee.

Status of HEOMD/Joint session with the Human Exploration & Operations Committee

The Science Committee joined the Human Exploration & Operations Committee in Room 9H40 for a joint session. After introductions, Mr. William Gerstenmaier, the Associate Administrator for HEOMD, presented a status of the directorate. The FY14 budget request has provided \$7.798B for HEO, based on some guiding principles. The primary objective is to use the International Space Station (ISS) to the fullest extent possible. Currently there is interest from the ESD and from the high-energy particle physics community in utilizing ISS assets. HEOMD will continue to advance human space flight capabilities through the development of Orion and the Space Launch System (SLS) heavy-lift launch vehicle; and develop a commercial crew capability to ferry humans to ISS. The commercial cargo industry is starting to deliver services, and is expected to be productive for the directorate. The ultimate goal is safe, reliable space access for NASA and NASA-sponsored payloads, while providing space communication and navigation, and supporting a small research program for low-Earth orbit (LEO) activity.

The budget estimates for FY 2015-18 are still notional; there is no detail on ISS below the top line, for example. HEOMD is striving for a better understanding of cargo/crew needs. The directorate is holding to

top line otherwise. Basically the budget is flat, which means HEOMD will be drive efficiency into its programs. It is critical to keep the commercial crew program in the \$800M region.

Mr. Gerstenmaier displayed charts on pre-PDR (Preliminary Design Review) Orion accomplishments; the heat shield has just arrived in Boston for its coating of ablative material. It is the largest heat shield NASA has ever manufactured, and is being prepared for a test flight in September 2014. An inert abort motor has been delivered to Kennedy Space Center (KSC) and a launch-abort system ogive panel has been delivered. The Orion capsule will be flown in 2021, and will be essentially the same vehicle that is currently being tested.

SLS accomplishments are several. There has been extensive wind tunnel testing, and design cycle analysis reviews have been very positive. A crew vehicle stage adaptor has been built at Marshall Space Flight Center, and a gas generator is being developed with an eye to potential for liquid boosters. Qualification motor casting was initiated at the contractor site in October 2012. The SLS program has real hardware to test fly in 2014, and will begin a manufacturing effort at the Michoud Assembly Facility. The year 2017 is not very far away; the vehicle must be at the Stennis center in 2016. Currently HEOMD is building up for a "Green Run" to validate the performance of the engines. The current intent is to hold a one-time development test.

The Antares A-ONE rocket is on the pad at the Wallops Island facility. Its initial flight was scrubbed the previous night due to a loose umbilical cord; the intent of the test flight is to look at fairing performance (the vehicle launched successfully on 21 April). Cygnus has been prepared for fueling and will go to ISS eventually; this unit will be integrated for launch in June 2013 for a demonstration flight (the Antares carried a dummy upper stage on the test flight).

The Commercial Crew Program continues to make progress. SpaceX has received NASA specifications in a phase 1 contract; a Request for Proposals (RFP) will be released for a phase 2 contract, on which anyone can bid. The intent is to award the contract in May 2014. The ISS research program has been particularly vigorous in the biology/biotechnology areas. A suite of Orbiting Carbon Observatory (OCO) instruments will be flown on ISS, to examine carbon generation at different times of day, complementing the measurements of the future OCO-2 satellite. ISS is hosting a total of 140 investigations; 82 US/NASA and 58 international, including more than 400 investigators. Responding to a question, Mr. Gerstenmaier affirmed that ISS is living up to its commitment on crew time (35 hours per week) devoted to science investigations. The communication system has also been upgraded; there are now 4 channels of communication, allowing two principal investigators (PIs) to work with 2 astronauts simultaneously, increasing science throughput. AMS has yielded early results in its search for dark matter; the instrument has looked throughout the cosmic sphere, and as yet no unique positron source has been found.

Addressing the asteroid retrieval mission called out in the FY14 budget, Mr. Gerstenmaier described the effort as one of aligning HEOMD and the Science Mission Directorate (SMD), while leveraging existing near-Earth object (NEO) observations. The mission will look for an object of 5-10 meters in size and use solar-electric propulsion (40kW SEP) for transport to and return of the target asteroid. SLS and multipurpose crew vehicle (MPCV) missions will be undertaken for a deep-space asteroid rendezvous. The mission will require unification between technology, science and human space flight efforts in order

to effect capture and control of uncooperative objects. There are three main segments of this mission: identify, redirect and explore the asteroid. The target object will have to be orbiting toward the lunar space on its own. The object will then be steered, via thrusters, to a deep retrograde orbit around the moon, which will remain stable for 100 years. The object must meet a large set of criteria. It is possible that an Apollo fragment may be initially misidentified as an asteroid. SEP, currently being developed in the Space Technology Mission Directorate, would eventually be transferred for use and operations within HEO.

It is believed that there are many near-Earth asteroids in the requisite size range for this mission, perhaps 1 or 2 per year that are close to the requisite criteria. The problem with these objects is that they are very fleeting and hard to see. Approximately 13 of the 300 known 10-meter class asteroids meet the orbital criteria. It will be necessary to openly talk about being unable to capture the object when it is encountered; this possibility should not be categorized as a mission failure. NASA needs to be careful about setting expectations. The size of the object is limited by the capture device, and asteroid density. Dr. Huntress commented that the asteroid criteria are pretty daunting; it must have the proper spin rate and it must be in the right orbit.

Mr. Gerstenmaier reviewed the interplanetary trajectory of the planned mission; 12 metric tons of xenon (Hall thruster) will be used to test its capability in terms of duration and impulse. Reaching the object will take 1.84 years and the traverse back to Earth 2.99 years. The spacecraft will approach the asteroid and match its spin rate. The capture device will have to be designed to null out nutation. The concept is currently thought of as a soft (inflatable) capture device. A hydrazine system will be used to de-spin the object, after which it would re-direct the asteroid back to Earth. Dr. Huntress noted that small asteroids could be spinning quite fast, or could be accretions of rubble. Mr. Gerstenmaier agreed that these were reasons to carefully define mission success. A participant commented that bringing an asteroid toward Earth could be perceived by the public as a hazardous undertaking. However, the target object was considered to be less hazardous than the asteroid that entered the atmosphere over Chelyabinsk, Russia in February 2013.

In terms of the Earth/Moon system trajectory, the closest flyby of the object to the Moon is 9000 km, after which it spins slowly into a retrograde orbit around the Moon. This orbit keeps the object between Moon and Earth gravity in a stable orbit. Responding to a suggestion to use a 2021 cruise mission for the mission, Mr. Gerstenmaier commented that the object cannot be obtained any sooner than 2024. However, HEOMD should be ready to launch to it by 2021. There is a calendar disconnect- this is a feasibility study only, not a mission design.

The retrieval mission will include a 22-day astronaut mission to visit the captured object via Orion. Orion is capable of allowing extravehicular activities (EVAs). In comparison to lunar mission, which needs a heavier vehicle and a lander, the retrieval mission requires far less equipment. In terms of planetary defense, the retrieval mission will advance the understanding of the composition, mass properties, and manipulation of near-Earth objects, yielding techniques and approaches. The management challenge will be in the operations of the retrieval vehicle, with very specific launch times. Mars program capabilities will be helpful in this effort. Dr. David McComas asked whether the Orion vehicle possessed adequate

shielding against space radiation events. Dr. Gerstenmaier replied that Orion has some capabilities, but the effects of a maximum solar event must still be determined. Radiation sensors will be flown on the test flight, and HEOMD will also do an analysis of the Apollo event. Dr. Janet Luhmann asked if HEOMD had plans to confer with PSD. It was noted that HEOMD will be holding a mission feasibility review this summer and will consult with PSD before that time. Augmentations of ground-based observations, feedback from the PSD Small Bodies Analysis Group (SBAG), and space weather support were also recommended as subject areas relevant to the mission.

The asteroid retrieval mission is considered a feed-forward activity within the long-term Mars strategy, as well as a demonstration of the ability to interact with a small planetary body. The mission can be viewed as part of a capability-driven framework for Mars, which will include SEP. Key strategies for executing the mission under the current budget, with modest increases include using high-TRL elements; utilizing near-term capabilities; involving commercial business; involving the international community, and setting up a multiple-use space infrastructure. HEOMD has conferred with the international community on the concept; there is general interest from an observation and mission design perspective. Russia is interested, particularly with regard to the Chelyabinsk incident. Meanwhile HEOMD is starting to identify the elements required by potential destinations. Orion is designed to augment a habitation module, functioning similarly to Apollo's Lunar Excursion Module (LEM). In summary, HEOMD is making excellent progress on Orion, and ISS is doing very well. The directorate continues to support the Deep Space Network (DSN), and SLS on a tight but workable budget. HEOMD will continue to plan asteroid redirection activities, as a means of developing an integrated Mars program. Asked if there was to be a competition for a new Commercial Resupply Service (CRS), Mr. Gerstenmaier indicated that no decisions had been made as yet.

#### Science Plan

The Science Committee reconvened in Room 7H45. Mr. Dan Woods, Director for Strategic Integration and Management, presented details of the developing SMD Science Plan. The plan is revised every 4 years to align with the Agency Strategic Plan. The current draft of the Science Plan has been reviewed by the four subcommittees, and Mr. Woods welcomed feedback from the Science Committee. The previous 2010 Science Plan will be used as a template for the new one. Proposed contents include an introduction, a description of the national agenda for science at NASA, the plan for Science at the Frontiers, and detailed plans by science area. This revision will be adding a principle: strategic decisions for future missions and scientific pursuits recommended in the NRC Decadal Survey and informed by national needs.

The Plan is also being challenged to identify ways to design and successfully implement programs that accomplish breakthrough science and applications, especially in terms of innovatively controlling cost in constrained times. NASA has already seen improvements in cost estimations that have resulted in missions such as Juno and GRAIL launching under cost and on schedule, based on some new ground rules such as requiring 70% confidence levels in mission cost and schedule estimates. Three new challenges derived from feedback provided by the subcommittees include controlling overall mission cost, training the next-generation workforce, and balancing risk with science payoff.

Mr. Woods asked the Committee to examine structure of the document, and to ascertain whether the identified principles, challenges and strategies were adequate. An Agency strategic goal specifically cited pertained to Space Earth and Agency Excellence (re: mission support at the Headquarters level). Dr. McComas commented that much of NASA's inspirational activity is largely in the science arena: How does Agency excellence get divorced from SMD? Mr. Woods replied that the intent of the stated goal is to look at how NASA operates. Dr. Brad Peterson noted that it was important that NASA be recognized as a model agency, because it is. Dr. McComas agreed that the tenor of the goal should reflect this latter sentiment.

The Science Plan is also seeking to update and make current the SMD Strategic Objectives for each of the four science divisions. Over the next year, the Plan will go through a series of reviews, with the intent to have a full draft ready by beginning of June 2013. It will then be submitted in parallel in July 2013 to the Office of Management and Budget (OMB), the Office of Science and Technology Policy (OSTP), and the Science Committee and its subcommittees, to integrate inputs. The goal is to develop a final draft by the end of the calendar year, for final release in early 2014.

Strategic Objective and Science Goals represent areas from which Government Performance and Reporting Act (GPRA) Modernization Act (GPRMA) metrics will be built for all divisions. Dr. Jonathan Rall commented that the first three Science Plan goals reflected Decadal Survey goals such as habitability and life beyond Earth, identifying hazards and resources, etc. Dr. Pieters commented that "advancing the understanding" sounds like more of the same stuff. Dr. Rall explained that such phrases are used by OMB to tie written goals to the measurement of performance by each division; part of the job in GPRA determinations is to roll up publications and press releases for the year; NASA can't set the bar so high that it can't get there. It's a balancing act that needs guidance from the community. Dr. Huntress noted that he had been around long enough to recognize that this wording makes the system work. Dr. Byron Tapley suggested adding or more explicitly calling out the description of planetary bodies as they exist now.

Mr. Woods reported that ESD is considering adding to the Plan an objective/goal of "improving the ability to assimilate global satellite data sets to improve predictions of events impacting life on Earth." Dr. Eugenia Kalnay noted that while the Committee feels a sense of urgency in, the goal text did not lend a sufficient feeling of urgency in addressing water/soil issues on the planet. Mr. Woods noted the comment for integration, while attempting to ensure that NASA is not put on the spot for meeting impossible goals.

Dr. Maura Hagan, Chair of the Heliophysics Subcommittee (HPS) noted that the HPS is currently updating the Heliophysics roadmap and had contributed language to the Science Plan in an attempt to make it more accessible. Dr. McComas commented that while he appreciated the wording, a description of the interaction with local interstellar medium had gotten lost; it needs to be in overarching statement and the first bullet. Mr. Woods noted the comment for re-addition.

Dr. Joan Centrella, representing the Astrophysics Division (APD), suggested some specific language relating to the origin and destiny of our universe (dark energy/gravity); origin and evolution of galaxies, stars and planets; and the discovery and study of habitable planets around other stars. Dr. C. Megan Urry noted that the language should be understandable to the general public. Mr. Woods agreed that specific details could be captured in chapters, while introductory statements could be more general in nature.

Mr. Woods briefly summarized next steps, and assured the Committee that “Version 1.0” of the Science Plan would be presented to all for further revision.

#### FY14 Budget Request Overview

Dr. John Grunsfeld, Science Mission Directorate (SMD) Associate Administrator, presented a budget overview. The budget is messy. Overall SMD is still doing exciting science, and is still well supported within the FY13 appropriation and the President’s FY14 budget request. NASA is still developing an Operating Plan for FY13. In spite of all the instability, NASA has enjoyed bipartisan support for SMD, particularly in climate science. Climate science was a primary topic in both the President’s Inaugural speech and State of the Union address. The Earth Science Division’s (ESD) Operation IceBridge has revealed Arctic sea ice levels to be the lowest in 100,000 years. The LandSat Data Continuity Mission (LDCM) satellite has observed hot dry conditions and water use in areas around the world, a classic application of LandSat data. NASA is very proud of this achievement. LDCM will become LandSat 8, eventually, for the US Geological Survey (USGS) to operate. NASA now has a requirement to lead the development of a plan for land imaging beyond LDCM. In other areas of science interest, the Sun has become remarkably quiet, the Curiosity rover is doing well. Curiosity has fulfilled its quest to determine habitability on Mars; its surface appears to harbor 30% clays in mudstone, with “water fit to drink,” and the presence of perchlorates that could be utilized as energy sources. Isotopic ratios (deuterium to hydrogen) indicate that when Mars sediment was laid down there was a thick atmosphere. The Mars program has not yet answered the question as to when this atmosphere existed and why it disappeared. Curiosity may find relevant evidence in the bedrock at the base of Mt. Sharp.

Astrophysics recently released an image of the Horsehead Nebula to mark the twenty-third anniversary of the launch of the Hubble Space Telescope (HST), previewing some of the capabilities of the James Webb Space Telescope (JWST). The four images on the cover of his presentation were described and it was noted that these four categories (Astrophysics, Earth Science, Heliophysics and Planetary Science) are indicative of how SMD does its accounting. However, science crosses these boundaries. The strength of NASA science is in its interdisciplinary connections. SMD does not want to pit science against science in a tough fiscal environment. NASA has also been given a new task, an asteroid retrieval mission, as well as direction to engage in a Large Synoptic Survey Telescope collaboration with the National Science Foundation.

NASA’s overall budget request is \$17.7B for FY14, and SMD’s portion is about \$5B. Years 2015-18 remain notional; the outyears keep the top line for NASA and science theme lines flat, and make adjustments within the programs. This does not take into account any sequestering in the 2014 budget. The President believes sequestration should be replaced with balanced deficit reduction and revenue increases. Dr. Grunsfeld believed that SMD is the most efficient science operation in the world, and



wanted to continue this. SMD is also trying to align the NASA workforce to focus on a number of specific areas.

The SMD budget strategy is to provide the most productive program possible, guided by national priorities and the Decadal Surveys, to responsibly manage national investment in robotic space missions, to increase NEO detection in support of future NASA initiatives, to begin a Mars 2020 mission (replicating the MSL architecture and taking advantage of engineering and design heritage to constrain the costs), to plan for land imaging beyond LDCM, responsibility for climate sensors on JPSS-2 and Earth science instruments on DSCOVR, and to implement the Administration's proposed STEM initiative. To this end, NASA is consolidating and removing duplication by moving the funding for STEM activities from SMD to the NASA Office of Education or the three domestic agencies tasked with leading the President's STEM initiative (i.e., Department of Education, National Science Foundation and the Smithsonian Institution).

Recent cost and schedule performance in a number of NASA programs have benefited from the requirement for a 70 percent confidence level in meeting cost and schedule; however, a 70 percent confidence level means that some missions will cost more and some will cost less than the estimate. Data from 2011-2012 indicate that NASA has been very successful in controlling costs; under the Operating Plans for FY12 and FY13, the Agency expects to report even better performance. The science budget request summary for FY13 reflects funding levels contained in the enacted bill, but have not been adjusted to capture reductions of about 7 percent contained elsewhere in the enacted appropriations bill; the FY13 Operating Plan funding level for SMD will be less than \$4.8B after rescissions and sequestration. The outyear budget is essentially flat except for JWST profiles at certain times. Budget changes in the outyears reflect variously the onset of new missions and operations ramping down.

### ***Astrophysics***

SMD has announced four new Explorer missions: two in the Heliophysics Division (HPD) and two in the APD. In APD, the Transiting Exoplanet Survey Satellite (TESS) mission and a mission of Opportunity (MoO) called Neutron star Interior Composition ExploreR (NICER; an x-ray astronomy payload on the International Space Station), have been selected. TESS will search for exoplanets, and will provide JWST with targets for further investigation. SMD is providing infrared detectors for ESA's Euclid dark energy mission. Spitzer, Planck, Chandra, Fermi, XMM, Kepler, Swift and Suzaku missions have been extended per the results of the latest Senior Review. Efficiencies in Fermi mission operations have been undertaken to reduce costs, and the Fermi Guest Observer (GO) program has been cancelled for one year. In addition, APD has rebalanced SR&T in all programs to implement Decadal Survey recommendations, with some reductions in the Cosmic Origins/Physics of the Cosmos program office budget. Budget items that remain the same for APD are HST, Stratospheric Observatory for Infrared Astronomy (SOFIA), NuSTAR, Astro-H, ST-7, the balloon program, Research and Analysis (R&A), and Astrophysics data archives. The budget for a large Decadal Survey mission will begin to grow in FY17 (along the lines of WFIRST, to meet its science objectives).

### ***Planetary Science***

What's changed in PSD's budget is an increase in capabilities for NEO observations, the new Mars 2020 mission, funds for the MOMA (organics detector) instrument on ESA's 2018 ExoMars mission, and the Electra communications system for ESA's Mars 2016 orbiter. The InSight mission (a Mars seismic sensor and heat flow experiment) has been selected. NASA is also accelerating the next Discovery Announcement of Opportunity (AO) by about 6 months. PSD has also selected US investigations on ESA's JUICE mission to Jupiter and its icy moons. In addition, NASA has received funding to support a restart of domestic Pu-238 production with the Department of Energy (DOE) including funding the infrastructure at DOE facilities needed to maintain this national responsibility..

### ***Earth Science***

The budget expands the Venture-class competitive flight program, and advances the development of the Stratospheric Aerosol and Gas Experiment (SAGE)-III mission for flight on ISS, Gravity Recovery and Climate Experiment Follow-on (GRACE-FO), Surface Water Ocean Topography (SWOT), Cyclone Global Navigation Satellite System (CYGNSS), OCO-3, Tempo, and ICESat-2; completes integration of DSCOVR's Earth-observing instruments, initiates study of how to provide for sustained Land Imaging System to support USGS; initiates development of a program for monitoring solar radiation, global ozone profiles, and Earth radiation balance starting with JPSS-2; supports pre-formulation studies for PACE, L-Band synthetic aperture radar (SAR), and other Decadal Survey-recommended missions; and funds a Carbon Monitoring System at \$10M/year.

### ***Heliophysics***

What's changed for HPD: the Ionospheric Connection Explorer (ICON) and the Global-scale Observations of the Limb and Disk (GOLD) mission have been downselected for development under the Explorer program. SMD has also added a new cubesat project for enabling scientific discovery for all four science divisions. What remains the same: there has been no change to launch readiness date (LRD) and life cycle cost (LCC) commitments for BARREL (balloon adjunct to the Van Allen probes), Magnetospheric Multiscale (MMS), IRIS, Solar Orbiter Collaboration and Solar Probe Plus. HPD is continuing prime operations for the Solar Dynamic Observatory (SDO), the Van Allen probes and extended operations for Geotail, Artemis, Solar TERrestrial RELations Observatory (STEREO), Time History of Events and Macroscale Interactions during Substorms (THEMIS), Aeronomy of Ice in the Mesosphere (AIM), Hinode, Cluster, Advanced Composition Explorer (ACE), Ramaty High Energy Solar Spectroscopic Imager (RHESSI), Solar and Heliospheric Observatory (SOHO), Thermosphere, Ionosphere, Mesosphere Energetics and Dynamics (TIMED), Voyager, Two Wide-angle Imaging Neutral-atom Spectrometers (TWINS), Coupled Ion Neutral Dynamic Investigation (CINDI), Interstellar Boundary Explorer (IBEX) and Wind.

### ***SMD Overall Budget Situation***

SMD boasts a total of 97 missions and 122 spacecraft in planning and operations, and is doing an impressive job. Dr. Huntress agreed, adding that the Committee is disappointed that the \$300M in planetary reduction continued in the FY14 despite the Congressional appropriation. A larger point is that the FY13 budget proposed reductions in planetary science to retain balance in other areas. Dr. Grunsfeld reiterated that "flat is the new up," and while it is true that there was a strong message from Congress to the contrary for planetary science, it came too late to be integrated into the President's FY14 budget

request. However, in December 2012, the Administration approved NASA contributions to ESA ExoMars and JUICE missions, as well as Mars 2020; these are major planetary efforts. Dr. Urry commented that the prior Education and Public Outreach (EPO) scheme (1 percent from each SMD mission) has to have been the single most successful effort ever, and that it makes no sense to change this. Dr. Grunsfeld agreed with this assessment, but he believed that the President wants to strengthen the effort across agencies in a consolidated way through other institutions, allowing the best to survive. Dr. McComas asked if any top-level guidance had been provided for budget allocations within various divisions from 2012-14. Dr. Grunsfeld replied that thus far, \$75M had been allocated for Europa in PSD, and other specific programs. The plan still has to go to OMB and is really about balance, not policy statements. Dr. Luhmann commented that it is good to see closer integration of HEOMD and SMD, but prospects for the outer solar system look dim; is there a vendetta against Europa? Dr. Grunsfeld noted that the cost estimate for a full-on Europa mission is \$4.5B, unfathomable in this budget environment. NASA has asked teams to study other lower cost options, resulting in a Europa “clipper” mission concept that is half the cost of the Decadal Survey recommendation.

#### Planetary Science Division Status

Dr. James Green, Director of PSD, presented a status of the division. As the budget dwindles, PSD is working hard to continue working with international partners on missions such as Bepi-Columbo, JUICE, ExoMars 2016/18, and Cassini. Curiosity continues successful exploration of Mars. GRAIL completed its three-month mission and its two spacecraft impacted the Moon; Dawn has mapped the asteroid Vesta and is en route to Ceres, MESSENGER has revealed volatiles trapped in Mercury craters, and Cassini has captured seasonal changes on Titan.

For FY14, PSD is moving ahead with a lunar dust characterization mission, called LADEE; MAVEN, a Mars aeronomy mission; OSIRIS-Rex, an asteroid sample return mission; and Curiosity operations. The division is also continuing research and development, including critical work in radioisotope power systems. For its part in the HEOMD Asteroid Retrieval Mission (ARM), PSD will expand its NEO detection and characterization activities to identify and study smaller NEOs that could be targets for ARM.. The overall budget includes the Lunar Quest program, which currently contains the Lunar Reconnaissance Orbiter (LRO), lunar science, and LADEE. LRO has funding through 2014, and will then go through a Senior Review to move forward. LADEE is designed for a relatively short primary mission. Rosetta, a comet lander mission, is healthy, representing a \$150M institutional investment.

Within the Discovery program, PSD is developing InSight, a PI-led mission to Mars that is scheduled to launch in 2016. It is moving to key decision point (KDP-C) this fiscal year (confirmation), and is looking good. Future Discovery lines depend somewhat on sequestration. MESSENGER has no extended mission budgeted at present; it will have to go through Senior Review. OSIRIS-Rex is going to confirmation shortly; its mission will be to retrieve a sample from a carbonaceous chondrite of 500 meters in diameter. Juno will reach Jupiter in 2016, and New Horizons will reach Pluto in 2015. An increase in New Frontiers management funds reflects the management of NASA’s instrument for the ESA JUICE mission. The Mars program has been reduced; NASA has stepped back from some major relationships with ESA in the Mars program. Curiosity is doing quite well and will compete in the mission extension line.

PSD has selected one instrument, an ultraviolet spectrometer, for JUICE. Cassini will be part of Senior Review in 2015; there is no future line currently associated with it. The Senior Review will be quite competitive. Within the three Technology lines there are: Advanced Stirling Radioisotope Generators (ASRGs), with a plan to complete two units and put them in bonded storage for later use; and studies of Pu-238 production. There is a new \$50M line in the NASA budget to support the Department of Energy's (DOE) radioisotope production infrastructure to maintain equipment, laboratory and facilities for plutonium generation. There will be a zero-base review, and the creation of a new governance model after it is understood what this \$50M buys. A Working Group will start up within the next month. The Committee expressed deep concern about a new "unfunded mandate" to operate a DOE lab, particularly as NASA lacks the expertise for this type of production

The total science budget is \$5.1B, reflecting a rescission of 2% and the 5% sequestration. Thus in total there is a \$16.6B top-line for NASA and \$4.8B for SMD. NASA is still waiting for guidance on these figures. The budget will be approved through OMB early in May. Steps NASA has taken to accommodate the reductions include cuts in training, travel, and conferences, but these steps as yet do not include furloughs or changes in hiring policy. SMD will respond to the impacts once they are fully known. Savings will be sought from forward funding, and there are no anticipated impacts on ongoing projects. Dr. Green presented a graphic summary for PSD, showing that PSD will operate effectively at \$1.22B including DOE money and the asteroid retrieval mission (ARM).

In other areas, OSIRIS-Rex is on schedule, and MAVEN is set to launch in November 2014, arriving at Mars in September 2015, in time to observe a comet flyby. Dr. Huntress observed that if nothing changes, PSD has lost 20% of its purchasing power, causing extreme stress in operations, and expressed concern that PSD would have to turn off assets. Dr. Green assured the Committee that the impact would probably push Discovery and New Frontiers out, but not eliminate them, and that he would continue to make planetary science his top priority.

### **PSS**

Planetary Science Subcommittee (PSS) Chair Janet Luhmann reported on subcommittee findings, the subcommittee having held a recent Webex meeting that addressed several topics, including JUICE, MSL, Research and Analysis (R&A), and various analysis group (AG) reports. She noted submission of proposals to a Solar System exploration virtual institute. PSS findings focused on cuts to the partially restored PSD budget, and extra taxes from prioritizations to come. The impact of budget cuts on R&A and the planetary workforce is of serious concern, as well as restoration of mission opportunities, and retaining expertise on instruments. The uncertain fate of a newly Europa "clipper" raises concerns about preserving Outer Planets expertise during this decade. The subcommittee is pleased that the Decadal Survey has weighed in on the Mars 2020 process, and also talked about development in NEO and private mission enterprises that could stand further discussion both at the PSD and Agency level.

The selection rates in planetary R&A are steadily declining. The selection rate has dropped from 35% to 24% while proposals and submittals increase. It is feared that coming reductions will reduce this rate to 10%. The trend of late has been steeper and steadier, making the ability to fund a career on R&A nearly impossible. The planetary AGs are still active and vital. CAPTEM continues sample curation and

allocation, and oversight of the meteorite collection; the Outer Planets AG (OPAG) discussed the final report from the Europa Science Definition Team (SDT), and is waiting to hear what happens next; the Lunar Exploration AG (LEAG) is busy with human exploration discussions. The future of lunar exploration is uncertain. Within the Venus Exploration AG (VEXAG), the report is that there is still much to be done at Venus. The community is awaiting another mission and has found no technological obstacles to doing so. The Small Bodies AG (SBAG) remains interested in the HEO and NEO programs, comets, operations at Arecibo, JWST, and transfer of responsibilities for the Antarctic meteorite program. The Mars Exploration Program AG (MEPAG) is actively engaged in the discussions about the Mars 2020 mission. They and the other AGS expressed concern about virtual meetings. MEPAG experimented with a large virtual meeting, and while it was useful, there are limitations in the communications it allows.

Additional concerns for PSS include the impact of sequestration, the apparent elimination of EPO, delays in Discovery and New Frontiers opportunities. OPAG worries about leadership in outer planets exploration; JUICE currently has no extended science mission program to support young scientists. OPAG has suggested studying small mission opportunities for the outer planets. SBAG expressed concern that they were not involved enough in NASA NEO activities and planning. For this community and in general, budget restrictions have resulted in a virtual ban on international travel to confer with international partners.

Dr. Luhmann reviewed some science slides, including the meteorite explosion in Chelyabinsk, the close approach of the asteroid 2012 DA14, and a potential comet impact on Mars in October 2014. There is a new distinctive Mars meteorite, and spectral evidence for an ocean on Europa (indicated by the presence of  $MgCl_2$ ).

In the subsequent discussions, Dr. Urry remarked on the oversubscription rates for proposals, decrying low rates as creating a lottery that is in turn counterproductive for continuity. The Science Committee considered a potential finding on R&A.

#### Earth Science Division Status

Dr. Mike Freilich, Director of ESD, presented a status, beginning his remarks by displaying a LDCM false-color image of the Fort Collins, CO area. LDCM is working well as it begins its operational orbit, phasing with the LandSat 7 satellite. At one point during the commissioning period, the two satellites were flying 20 km apart, one under another, took images, and thus could be cross-calibrated. LDCM will be re-named LandSat in May when it is turned over to USGS for operation. LDCM is capable of thermal infrared imagery at 100 m resolution, important for monitoring water use.

The ESD FY14 budget is above and consistent with the FY12 and FY13 requests. The division has had a period of relative stability that is continuing. Dr. Freilich reminded the Committee that ESD competed science teams are able to obtain some funding out of mission lines. Some change has occurred in program content, but the funding level is more or less the same. The Administration has requested increased content from ESD, reflecting its importance to the nation. The budget initiates a new Land Imaging project for development of a national sustained Land Imaging Satellite System. NASA will operate this system with USGS. Approximately \$30M has been allocated for this in FY14, a total of \$445M from

2014-18. NASA will have responsibility for the spaceborne components, and will operate the spacecraft and provide communication links. Another increase in scope is in new NASA responsibility for climate sensors that previously were owned by NOAA: TSIS, OMPS-LIMB, and CERES (\$40M in FY14). Operations for QSCAT, Jason-1, CloudSat, Global Recovery and Climate Experiment (GRACE), and Solar Radiation and Climate Experiment (SORCE), will end by 2018, as these missions are well beyond their lifetimes. ESD's educational GLOBE program will remain within NASA and will not be transferred to the Office of Education.

The 2013 ESD Senior Review will cover 17 missions and will evaluate both science and national interests associated with these missions, as well as contributions made to other agencies (e.g., NOAA, DOD). Launches scheduled for 2014 are OCO-2, Soil Moisture Active Passive (SMAP), Global Precipitation Mission and SAGE-III (occultation/atmospheric measurements on ISS). There are 7 more missions in 2015-2020, including ICESat 2, TEMPO (first of the Venture-class instrument missions) which will be flying with ESA and South Korean geophysical platforms making simultaneous measurements, CYGNSS (unique because it will operate at L-band, virtually unaffected by precipitation, allowing surface wind speed measurements, will aid hurricane intensity predictions). The remaining launches will be GRACE-FO, OCO-3 (on ISS), and PACE (ocean color).

Within Venture class, all five EV-1 suborbital investigations have completed at least one field campaign and will fly during 2013. CYGNSS is an EV-2 mission. EV-1 (instrument) is TEMPO, selected for a GEO-hosted payload opportunity in 2017. The second EV-1/2 solicitation has been funded and is scheduled for release. ISS Earth science instruments include SAGE III and OCO-3. RapidSCAT, made from spare parts from QuickSCAT, is scheduled for 2014. ESD has attempted to keep a balanced program between flight and non-flight (research, applied science, technology development) programs; 35-40% of the program is non-flight. Some experiments are on ISS only for bookkeeping purposes, but in most cases ISS is not appropriate for Earth observations. The ISS orbit itself is not high-precision, and has limited latitude coverage. It is good for some niche measurements. Asked how much is actually known about the debris cloud around ISS, Dr. Freilich replied that Johnson Space Center (JSC) tracks the debris. An experiment called MISSE also addressed this, measuring deposition of particles over time, and the effects of atomic oxygen.

### ***ESS***

Dr. Tapley, Chair of the Earth Science Subcommittee (ESS), reviewed recent ESS findings, compiled during its most recent teleconference held to review the budget, Science Plan, and its response to the NAC Information Technology Cyber-infrastructure Initiative. The heart of the NASA cyberstructure sits in the Earth Observing System Data and Information System (EOSDIS), initiated in 1990; it is currently a petabyte-scale archive of Earth observation data, dealing with the addition of a wide range of data and the generation of broad range of data products on a daily basis for dissemination to a large international community over a distributed information network. EOSDIS handles a terabyte of new data per day from a large number of satellites, representing a very inhomogeneous set of data. What is unique to Earth science requirements is that most of the data needs to be brought together with some sort of commonality to look at Earth in a holistic sense. The implementation of data operations occurs between mission operations and science operations. The Earth system-modeling effort uses much of this data. There are 12

discipline-oriented (ocean, land) data centers, all effectively connected. EOSDIS evolved over 15 years, meeting its needs well, providing roughly 7000 unique data products. Data volume is extremely high, with an average archive growth of 5 Tb per day. The archive volume is currently 6 petabytes, representing an extremely large number of national and international users.

Given the complexity of the system, there are places where it can be improved. ESS recommends, that with regard to the IT initiative, that ESD conduct a self-study within SMD to compare its existing infrastructure with the best of breed, focusing on areas where science productivity is limited and where data bottlenecks reside. A major caveat is that the self-study should not disrupt information flow to the current science and application user community. Dr. Huntress preferred that all four subcommittees weigh in on the recommendation before it is brought up to the level of the NAC. Dr. Kalnay expressed surprise that there was no hint of being constrained by lack of storage space. Dr. Tapley observed that while there was no identifiable lack in storage capability, there is an issue as to the rapidly changing capabilities in the field; a faster calculation mode is out there but one doesn't want to break the system in trying to incorporate it. Dr. Hagan discussed the HPS view of the initiative, which had considered disruptive technologies and how they might impact codes in the near term; who controls software, how to manage software, standards control, efficiencies, cost/benefits of new versus old technology. New hardware raises those issues. Any change needs to be carried out in an evolutionary manner. Dr. Freilich added that 10% of the ESD budget is focused on data assimilation.

#### Joint Agency Satellite Division

Ms. Cathy Lapenta presented a status of the Joint Agency Satellite Division (JASD), whose main reimbursable partner is the National Oceanic and Atmospheric Administration (NOAA). She gave a brief background of the division, which operates uniquely, as all its requirements are operational. JASD was established when NPOESS was transitioned to the new Joint Polar Satellite System (JPSS) and Marcus Watkins is the Director. JASD uses all the NASA programmatic requirements in advancing its programs. The division provides a single Headquarters interface for partner Federal agencies and performs the typical role for NASA projects. However, science is not done within JASD. Rather it relies on other science divisions to represent NASA science requirements. Decision authority and responsibilities for strategic planning remain with the customer. Current planning for JASD goes on through 2024. The FY14 budget, based on NOAA's rollout, will support the Geostationary Operational Environmental Satellite R-Series (GOES-R), DSCOVR, Jason-3, and JPSS satellites.

NOAA operates the US civilian operational polar satellite system, including the NPOESS Preparatory Project (NPP). The European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT), the Department of Defense (DOD) and the Japanese Space Agency (JAXA) are NOAA partners for weather and long-term research. There have been no changes in FY14 budget for JPSS-1. SarSAT-2 has been removed from the JPSS program. Various other changes are expected to reduce the JPSS program LCC by about \$1B. S-NPP has been operating successfully for over a year, and all JPSS-1 segments are on track to support a launch no later than the second quarter of FY17. GOES-R and GOES-S, the next generation of geostationary satellites, are progressing toward launches in 2015 and 2017, respectively. NOAA leads the development of ground systems for GOES. The GOES instrument suite includes an advanced baseline imager to measure cloud properties, geostationary lightning mapper, a

large suite of space weather instruments, and also functions for telecommunications. For the Jason-3 project, NASA is managing and developing 3 instruments for ESA. Jason-3 will continue global measurement of sea surface height.

For DSCOVR, NASA is refurbishing instruments and spacecraft; integration and testing are going very well. The DSCOVR launch vehicle will also support a secondary payload from the Space Technology Mission Directorate (STMD), a SunJammer solar sail demonstration. The Polar Free Flyer will be flying a total solar irradiance sensor (TSIS) in a launch scheduled for the summer of 2016 timeframe. A TSI Calibration Transfer Experiment will be flying on an Air Force launch vehicle in September 2013, measuring total solar irradiance in an attempt to avoid gaps resulting from an earlier GLORY satellite failure. Asked how JASD advertises its services, Dr. Grunsfeld explained that the acquisition relationship with NOAA is historical, as Goddard Space Flight Center (GSFC) has built many NOAA spacecraft. NASA provides engineering expertise, but open competition for spacecraft and instrument procurements is used. NASA works closely within the customer environment. All confirmation reviews are joint, and major decisions are made in joint forums. The major difference is that the funding comes from a different government appropriation; the industrial base is the same.

#### Discussion

Dr. Huntress raised several issues for potential findings: thoughts on the asteroid retrieval mission, the decline in R&A proposal selection, and the transfer of educational efforts out of SMD, the last issue being one that the Committee felt should be brought to the Administrator's attention. The Committee also considered the risks and costs associated with NASA's proposed management of DOE facilities for Pu-238 production, as NASA does not possess core capabilities for producing nuclear materials. Dr. Luhmann observed that major changes have taken place within SMD since the most recent Decadal Surveys were written. Dr. Urry was disturbed by ESD's approach to utilizing the assets of ISS, remarking that Earth science costs more and is not effective when carried out at ISS. Dr. Tapley noted that ESS did review ISS science at length in the recent past.

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Dr. Feeley queried Committee members as to their views on virtual meetings, in view of sequestration and travel restrictions that could soon be imposing limits on Advisory Committee meetings. Committee members discussed the pros and cons of Webex and teleconferences, Adobe Connect, Google Plus, and VIDYO software technologies. In general, the Committee concluded that virtual meetings are insufficient for conducting the necessary business of advising NASA. Dr. McComas suggesting consulting Larry Smarr on the matter of virtual meeting technologies, and recommended that whatever the solution, it must be owned by someone at NASA Headquarters. Dr. Feeley took an action to work with the Information Technology (IT) experts to provide better teleconference support.

#### Heliophysics Division

Dr. Jeff Newmark presented an update of the HPD status. HPD has provided new text for the SMD Science Plan that is currently under revision. The Heliophysics System Observatory continues to utilize a large fleet of spacecraft to sample the entire Sun-Earth system, with 18 operating missions from low-Earth orbit (LEO) to the outer reaches of the heliosphere. HPD is planning two new Explorer missions;



ICON, which will study neutron-ion coupling in the upper atmosphere, representing a new area of study. As the ionosphere is affected by both terrestrial and solar weather, ICON will be looking at the drivers of this phenomenon. GOLD is a new Explorer mission that will work synergistically with ICON. GOLD will launch on a commercial satellite, and carry an imaging spectrograph to study the thermosphere and ionosphere. Both will launch in 2017 to carry out two-year missions. Science highlights in HPD include continuing data from Voyager 1, whose observations continue to drive new theory about the reaches of the heliopause; IBEX observations of the outer heliosphere, providing more information about the ribbon, structure, and tail regions of the solar boundaries. SDO viewed both Earth and lunar transits on the same day, and captured a view of a solar prominence. The solar cycle continues to be mysterious; it is not yet known whether the solar peak has been reached, as the Sun's hemispheres are not in synchrony in terms of activity.

Black Brant motor issues in the sounding rocket program are still being worked, entailing a move back to a prior design. The change has had an impact on safety rules, particularly at the White Sands range. A campaign at Kwajalein will begin with a launch window opening on 26 April. The Van Allen probes were successfully launched in August 2012. IRIS is scheduled to launch on 26 June, a Space Environmental Testbed (SET) will be launching on DMSP, and Solar Orbiter Collaboration (SOC) and Solar Probe Plus (SPP) are on schedule for the 2017/18 time frame. Flight program highlights include the successful deployment of BARREL balloons in Antarctica. BARREL is a mission that makes observations in concert with the Van Allen probes. A second BARREL campaign is planned for next winter. MMS continues development, SOC passed KDP-C for US instruments, and SPP continues in formulation, moving toward KDP-C. The HPD Senior Review will begin in the third week of April and issue its final report in late Spring.

ICON and GOLD, a full mission and MoO, are new to the budget. HPD will be managing a new CubeSat program for the entire SMD at a cost of \$5M/year; the program will be run similarly to the way HPD manages the sounding rocket program for SMD. There has been no change to the operations status of current missions. The top line for HPD program content is \$653.7M. This amount covers some non-HPD activities; FY14 looks to be increased but is not. In the research line, Dr. Newmark pointed out that the \$70M is not specific to HPD, but rather represents funds managed for the entire SMD. The HPD budget in the outyears is relatively flat. Dr. Newmark also noted that a Directed Research and Technology (DR&T) line bookkeeps money for civil servants. Dr. Grunsfeld added that this line responds to center requests for various levels of support, which varies as people roll off and on projects. The funding line is managed by center directors, although the budget resides in HPD. In the long term, the arrangement is for SMD benefit, which receives an accounting of work performed, helping to inform plans for workforce changes. The Living With a Star (LWS) program is budgeted at \$216M in 2014, to be phased with the Solar Terrestrial Probe (STP), program, which has \$146M in 2014. The Explorers program is set at \$95M in 2014. Overall for 2013, HPD is down about 6.5% from the President's request (\$43M). The next Explorer Announcement of Opportunity (AO) is expected in 2016, and the next STP AO will probably be in the same timeframe, depending on when MMS launches.

### ***HPS***

Dr. Maura Hagan, Chair of the Heliophysics Subcommittee (HPS), reviewed the outcome of its April

meeting. The meeting provided the first opportunity to digest the initial draft of the Heliophysics roadmap and the SMD Science Plan. The subcommittee also discussed the timing of the Senior Review and the status of the competed research line. A major charter for roadmap was to align it with the Decadal Survey, given that the Survey is larger in scope and contains implementation guidelines, cost caps and priorities commensurate with resources in HPD. The Survey calls for the implementation of the DRIVE initiative, diversification of observing platforms, sufficient funding for Mission Operations and Data Analysis, acceleration and expansion of the Explorer program, a restructuring of STP to include a moderate PI-led mission line, and the implementation of a large LWS mission. A major HPS concern is the budget impact on priorities and plans. It is important to note that the Decadal Survey anticipated budget growth, a very optimistic viewpoint compared with the current reality. As a result, the HPD roadmap has required a revision with updated budget guidance. The FY14 budget impact will affect the cadence of strategic missions starts and the call for Explorer augmentation. The DRIVE initiative will be delayed, and therefore Heliophysics cannot realize the Decadal Survey strategy in the anticipated timeline.

HPS has concluded that the guiding strategies for reacting to the FY14 budget are to remain flexible, identify cost growth early, and protect the research program. The subcommittee recommends therefore that HPD urgently investigate and pursue strategies to reduce mission costs so that top priority recommendations of the Decadal Survey can be implemented in a timely fashion.

The Decadal Survey had a series of recommendations to expand and keep vibrant the Guest Investigator (GI) program, establish a “tiny sat” program, and augment interdisciplinary science centers. HPS is concerned about the health of the current GI program, the impact of sequestration, the growing number of submissions and declining selection rate in the R&A program; EPO; and open data policy with respect to international partners. HPS has recommended that HPD continue its mandatory open data policy.

Dr. Hagan reviewed science highlights: the observation of a third temporary radiation belt around the Earth, the high resolution images of the solar corona, the fifth anniversary of CINDI, a mission that has yielded new understanding of the behavior of the nighttime low-latitude ionosphere. Due to the sequester, the US Air Force will probably be turning off its CNOFS satellite (and thus CINDI).

#### Astrophysics Division Status

Dr. Paul Hertz, Director of the Astrophysics Division (APD), briefed the Committee on the division status. APD is maintaining a capable suite in space. JWST is on schedule for an October 2018 launch, within cost, and the division is continuing a robust R&A program through the ROSES and GI programs. Budgetary impacts for the future remain uncertain. The smallest known exoplanets in the habitable zone have just been discovered: Kepler 62e and f. Early indications are that these planets are rocky. NuSTAR has helped to solve a riddle of black hole spin, providing data that falls exactly along predictions of space/time distortion due to the rotation of the supermassive black hole.

Two new Explorers have been selected: the Transiting Exoplanet Survey Satellite (TESS), a transit survey for viewing the 500,000 nearest and brightest stars to select the nearest neighboring exoplanets for JWST follow-up investigation. Neutron Star Interior Composition ExploreR (NICER) is a MoO, an x-ray timing instrument to be mounted on ISS. NICER is designed to answer fundamental questions about

extremes in gravity, material density, and electromagnetism, and is co-sponsored by the NASA Space Technology Program. NICER will also test a cosmic “GPS” for interplanetary missions.

Kepler is in its extended mission phase and has experienced the loss of one reaction wheel, leaving three functioning. Wheel 4 shows indications that it might fail soon, thus the mission is trying to determine whether two-reaction-wheel operations are scientifically valuable. This may be sorted out in the Senior Review. Kepler has observed 300 confirmed exoplanets. Dr. Hertz noted that a 500-person, European-led consortium has been using Kepler to study stellar variability; the mission is revolutionizing the knowledge of stellar interiors. Kepler is also linked to a citizen science project called Planet Hunters, which has resulted in at least one exoplanet discovery.

The Stratospheric Observatory for Infrared Astronomy (SOFIA) is beginning to commission instruments, interleaved with GO science; its first Southern hemisphere deployment will occur in July 2013. APD will release an advanced instrument AO for SOFIA in July 2014. Efforts are currently in progress to upgrade a focal plane imager to better than one arc-second. This year the mission will reach 200 science flight hours; within 4 years it will reach its Level 1 requirement of 960 science flight hours per year. Astro-H, NASA’s contribution to a JAXA mission, is undergoing thermal vibration testing of an engineering unit. The cryocoolers have been found to be transmitting vibration into the microcalorimeters and thus will require isolation. NASA has been restructuring its cost and schedule to accommodate JAXA’s new launch date in 2015. AFTA (Astrophysics Focused Telescope Assets) is a mission tied to the Decadal Survey’s recommended WFIRST dark energy mission. APD has been studying optical assets offered by the National Reconnaissance Office (NRO) for this purpose; the results of an SDT report will be reported to the Administrator by the end of May. If approved, APD will continue to study a design reference mission. AFTA will be designed to be modular and serviceable. The NRO assets were also studied for other NASA objectives, in response to a call for concepts. A NASA team gelled approximately 30 concepts into 7 representative ideas that were briefed to the senior management. At the moment, only the astrophysics concept is being studied. Dr. McComas recommended that the NAC SC get to see the report from the Study for the Application of Large Space Optics (SALSO). Dr. Feeley took an action to obtain this report.

The FY13 appropriation for APD was actually \$10M over the President’s budget request, meant for initiating WFIRST science, and JWST also had received an appropriation as requested. APD must now apply cuts, at 6.8% lower than the requested \$659M. The Operating Plan will contain final numbers. To accommodate reductions, the division intends to reduce carryover for operating and developing missions, (this may involve re-phasing GO funds); re-phase unneeded FY13 funds for developing missions; re-phase R&A funding (the division is contacting PIs with uncosted funding); and slow down development of future Explorers. APD will likely create liens in FY14, lower R&A selections, delay future AOs, and make other reductions where necessary. The first things to defer will be any new selections.

What’s new in the budget request are two new Explorers, participation in ESA’s Euclid mission, a line to support a Senior Review, and the reduced operations cost of the Fermi extended mission. APD cannot support selections for the 2012 AP Explorer MoO. An AO for this Explorer was released last fall; APD has informed PIs, is completing evaluation of the proposals, and will debrief the proposers eventually on

this cancellation. The plan is to allow the proposers to re-propose against a new future AO, perhaps in FY16. JWST is fully funded, however, as are Data Analysis and archives. APD published an implementation plan in December 2012 for meeting Decadal Survey recommendations under current constraints. The division is doing SDT studies for 3 different versions of WFIRST, or a medium-sized mission that would advance the priorities of the Decadal Survey. APD is anticipating a mid-decade review and a new mission start no earlier than 2017, if funding is available. ESA will be selecting two missions to follow JUICE, and NASA is prepared to partner with them if the missions are relevant to the Astrophysics Decadal Survey. APD will get interim reports from the AFTA SDTs in Spring 2014, final reports in Winter 2015, as well as an independent cost estimate on each design reference mission (DRM). APD is also asking the NRC to review the DRMs for their responsiveness to the Decadal Survey.

### ***APS***

Dr. Bradley Peterson, Chair of the Astrophysics Subcommittee (APS), reported results of the most recent APS meeting. Top issues considered by APS were redirection of EPO funds from SMD, which APS believes removes content and context from educational products. The subcommittee also discussed the urgent problem of the loss of Astrophysics expertise that has been built up over decades, and NASA's reduced buying power to carry out the Decadal Survey's recommended missions. Other concerns were raised about APD's flexibility to move funds around in its mission envelopes, travel policy disproportionately affecting scientists, and the recent cancellation of the MoO selection. APS noted that the AP Roadmap team has been carefully selected as to expertise (exoplanets, cosmic origins, physics of cosmos) and is now reviewing abstracts from the community. A virtual town hall meeting will be held in early May, and a final Roadmap report is expected by mid-December.

### James Webb Space Telescope

Mr. Geoff Yoder gave an update on the progress of JWST. The mission has been focused on execution, and teamwork with the GSFC has been working very well. The mission has developed a tighter relationship with code 400, and has been producing a monthly report to help ferret out early indicators via earned value management (EVM) practices, as well as conducting all-hands meetings at both center and contractor sites. Dr. Eric Smith is leading the development of the JWST communication plan..

All 18 JWST mirror segments have been built and characterized. It has been necessary to change motors due to loose, mismatched bearings observed in bearing races during testing; six motors have been replaced and three are in work. The mirrors are currently 16 months ahead of schedule. All five sunshield templates have been built; one key activity in this area is folding. Previous concerns with sunshield waviness and wrinkling have been resolved. In preparation for spacecraft CDR in December 2013, Program Office requested that ESA conduct a launch vehicle mass margin study with the launch vehicle provider Ariespace to see if there is additional mass potential on the Ariane 5. In response, ESA has increased the mass specification by 90 kg, adding a level of comfort to mass planning.

JWST aims to have the bulk of subsystem reviews done by midsummer 2013, well before CDR. Two of four flight instruments are now in-house at GSFC. The near-infrared camera (NIRCAM) stray light issues have been resolved, and the instrument is on track to be shipped to GSFC for vibration testing. The near-infrared spectrometer (NIRSPEC) has undergone cryovacuum testing; the schedule to install the

redesigned kinetic mounts are tighter than desired and this attribute is being tracked closely. The mid-infrared instrument (MIRI) and the fine guidance sensor (FGS) instruments have been tested in parallel operation with flight-type software; this is working well. Other sub-elements are progressing well. New NIRCAM shortwave detectors are a year ahead of schedule and have been shown to be significantly better than previous detectors, which had suffered migration between indium and gold, problem found simultaneously by an other customer. Long-wave detectors are progressing well. The FGS has been installed into the Integrated Science Instrument Module (ISIM) structure, and the MIRI will be installed next week. Three milestones are sliding, two due to limited access to test chambers at GSFC. The third milestone is based on a shield on MIRI, which required additional work. The number-one risk issue is the cryocooler, which is getting a lot of attention.

#### Planetary Protection Subcommittee

Dr. Eugene Levy, Chair of the Planetary Protection Subcommittee presented a status on PPS issues. Recently PPS has recommended that NASA develop a procedural requirements document (NPR) to specify planetary protection measures for human extraterrestrial missions. Work on this NPR has begun. In addition, PPS called for the development of Lessons Learned study to address planetary protection (PP) issues on the Mars Science Lander (in progress); and for the extension of a Letter of Agreement (LOA) on the historically effective NASA-ESA cooperation on PP efforts. PPS harbors ongoing concerns for PP within the Agency. These include technology development for PP, the provision of resources for essential, minimal science and technology studies supported by the Planetary Protection Officer (PPO), and adequacy of staffing levels for PPO.

Dr. Cassie Conley, NASA PPO, briefly described the areas of expertise needed for PP; the formulation of policy decisions via the international body, the Committee on Space Research (COSPAR); technology development for PP; the goals of science and the preservation of the capability of understanding the origin of life in the Solar System; and monitoring of PP implementation. PPO sits within SMD, and reports to SMD AA. The PPO must also interface with HEOMD and the Space Technology Mission Directorate, and must coordinate within the US beyond NASA, with agencies such as the Centers for Disease Control, the National Science Foundation, DOE, and the Office of Science and Technology Policy. In terms of international cooperation COSPAR provides the sole arena for pan-agency coordination. It is important that these interagency conferences continue. Asked if PP concerns were being addressed for the proposed asteroid return mission, Dr. Conley reported that the mission is being analyzed in terms of the potential for backward contamination, and as an opportunity to establish good practices for future human exposure to interplanetary materials. The World Health Organization (WHO) is working with the UN on this matter, as is COSPAR. Dr. Luhmann mentioned the extremophiles (tardigrades) that had been intentionally included on the Phobos-Grunt mission to the Mars system. Dr. Conley noted that both she and the ESA PPO had traveled to Russia twice to confirm that Phobos-Grunt was using orbital requirements to keep contamination from occurring. There was no violation of the current treaty. Dr. Luhmann suggested it might be useful for the PPO to issue formal statement in these cases. Dr. Levy commented that planetary protection remains a critical issue, and is especially significant in that PP is such a unique technology that has little application elsewhere, and thus requires special attention. In general, planetary protection is an extremely important issue for all aspects of NASA.

Discussion with AA

The Science Committee conferred with Dr. Grunsfeld. Dr. Luhmann asked what message SMD might send to the community as a whole given the budget issues. Dr. Grunsfeld replied that the sequester cannot be permitted to affect the enthusiasm of community and students. NASA still has billions of dollars in invested in space, and there are enormous opportunities to be had. If the community fails to present compelling proposals, ideas will continue to decline; important science topics must be communicated to a broader audience. Science is interesting and important to the public, and valued by the Administration and Congress.

Asked when a new director for HPD would be selected, Dr. Grunsfeld reported that interviews will have been completed by the end of that day, and a new director should be in place within three months. Dr. Urry commented that research areas such as particle physics are underfunded at an order of magnitude below the typical level for Astrophysics; this is not the way to extract optimal value from US scientists. Dr. Grunsfeld agreed that funding was a challenge. Drs. Peterson and Green added that review panels become more selective as a result, and also strain the operational staff within NASA to cover the calls. PSD experimented with a two-step process research call that did not work. HPD is doing a similar experiment but is getting better results; PSD plans to take those lessons learned and apply it to its R&A calls. There is a group actively looking at this. Under the Continuing Resolution, PSD gave an allotment to every R&A call, and sent out select, selectable (PI gets money if and when it becomes available), and reject letters. Asked why the two-step process failed for PSD, Dr. Green noted the calls took more time, not less. PSD is also trying to pick up the more efficient aspects of the NSF process.

Dr. Kalnay noted that the most serious crisis for the community is climate change: is it possible to make the message louder? Dr. Grunsfeld commented that the scientific community, as individuals, can make the message louder. In the realm of civil service, NASA must be very careful about stating science as opposed to policy. As a scientist, he felt a great responsibility to discuss what is known and not known, and to prepare. The largest community of influence is parents; this is a big challenge. Climate change will likely drive most of the economic stress. Dr. McComas remarked that the high-energy physics community lost it opportunities by not communicating well, and likened this situation to the change in EPO structure: how can we retain the educational aspect and not lose the battle? Dr. Grunsfeld felt that NASA is not a marketer. The Agency educates and informs, and is committed to wide dissemination of results. NASA can use its educational outreach program to continue to influence young minds, which will be the future of all business, medicine, advanced technology, legislators, etc. He agreed that NASA should continue to do these important things and welcomed advice from the Science Committee. Dr. Green noted that in EPO the trend has been to move STEM to create curricula to meet science objectives, and NASA absolutely must make websites publicly available so that experts can still support STEM. Dr. Urry commented that NASA and the nation gets a lot of free labor from scientists in terms of education, none of whom are going to be working with the Department of Education. Dr. Grunsfeld held to the idea that the educational opportunity energizes scientists; the model is still in work.

Public comment period

No public comments were noted.

Findings and recommendations discussion

The Science Committee addressed the wording of findings on asteroid capture, NASA management of DOE assets; and the transfer of EPO management within the NASA enterprise. Dr. Peterson noted for the record that APS had weighed in specifically on this issue in its recent findings. Further discussion ensued on the tight funding in R&A and protecting the grants budgets. Dr. Huntress agreed to work on appropriate language addressing R&A. As to the NASA budget, Dr. Huntress suggested the Committee re-submit its previous year's recommendation, as the situation was virtually unchanged.

It was noted for the record that Dr. Huntress had conducted his last meeting as Science Committee Chair, and the membership welcomed Dr. McComas as its incoming Chair.

## Appendix A Attendees

### NAC Science Committee members

Wesley Huntress, Carnegie Institute, *Chair*  
Maura Hagan, NCAR, Chair, Heliophysics Subcommittee  
Byron Tapley, University of Texas, *Vice Chair* and Chair, Earth Science Subcommittee  
Eugenia Kalnay, University of Maryland  
Janet Luhmann, UC Berkeley, Chair, Planetary Science Subcommittee  
Eugene Levy, Rice University, Chair, Planetary Protection Subcommittee (via telecom)  
David McComas, Southwest Research Institute  
Bradley Peterson, Ohio State University, Chair, Astrophysics Subcommittee  
Carlé Pieters, Brown University  
Meg Urry, Yale University  
T. Jens Feeley, NASA Headquarters, *Executive Secretary*

### NASA Attendees

Barbara Adde, NASA Headquarters  
Marc Allen, NASA Headquarters  
Louis Barbier, NASA Headquarters  
Stephen Berrick, NASA Headquarters  
Joan Centrella, NASA Headquarters  
Jonathan Cirtain, NASA MSFC  
Steve Cole, NASA Headquarters  
Catharine Conley, NASA Headquarters  
Teresa Fryberger, NASA Headquarters  
Michael Freilich, NASA Headquarters  
John Grunsfeld, NASA Headquarters  
Hashima Hasan, NASA Headquarters  
Paul Hertz, NASA Headquarters  
David B. Jarrett, NASA Headquarters  
Deirdre Jurand, NASA Headquarters  
Cathy Lapenta, NASA Headquarters  
Robert Leamon, NASA Headquarters  
Lisa May, NASA Headquarters  
Cheryl Moy, NASA Headquarters  
Martha Maiden, NASA Headquarters  
Roy Maizel, NASA Headquarters  
Sean McCantle, NASA Headquarters  
Michael Meyer, NASA Headquarters  
Michael New, NASA Headquarters  
Jeff Newmark, NASA Headquarters  
Marian Norris, NASA Headquarters  
Jonathan Rall, NASA Headquarters  
Andrea Razzaghi, NASA Headquarters



Diane Rausch, NASA Headquarters  
Christy Rivera, NASA Headquarters  
Eric Smith, NASA Headquarters  
Rita Sambruna, NASA Headquarters  
Ray Taylor, NASA Headquarters  
Lucia Tsaoussi, NASA Headquarters  
Nicholas White, NASA GSFC  
Dan Woods, NASA Headquarters  
Geoffrey Yoder, NASA Headquarters

Non-NASA Attendees

Tammy Dickinson, OSTP  
Walt Falconer, Strategic Space Solutions  
Brad Keelor, British Embassy  
Jim Lochner, USRA  
Steve Mackwell, LPI, USRA  
Jon Malay, Lockheed Martin  
David Parker, British Embassy  
Ana Wilson, Zantech IT  
Joan Zimmermann, Zantech IT

Appendix B  
NAC Science Committee Membership

Dr. Wesley T. Huntress, Jr.  
Carnegie Institution of Washington (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. David McComas  
Southwest Research Institute

Dr. Bradley Peterson  
Ohio State University

Dr. Meg Urry  
Yale University

Dr. T. Jens Feeley  
Executive Secretary  
NASA Headquarters

Appendix C  
Presentations

1. Human Exploration and Operations Mission Directorate Overview; *William Gerstenmaier*
2. NASA Science Plan Status; *Dan Woods*
3. Science Mission Directorate Status, FY14 Budget Overview; *John Grunsfeld*
4. Planetary Science Division Status; *James Green, Janet Luhmann*
5. Earth Science Division Status; *Michael Freilich, Byron Tapley*
6. Joint Agency Satellite Division; *Kathy Lapenta*
7. Heliophysics Division Status; *Jeff Newmark, Maura Hagan*
8. Astrophysics Division Status; *Paul Hertz, Bradley Peterson*
9. James Webb Space Telescope Status; *Geoffrey Yoder*
10. Planetary Protection Status; *Cassie Conley, Eugene Levy*

Appendix D

NAC Science Committee  
April 18-19, 2013

Agenda  
(all times EASTERN)

Thursday, April 18 (MIC-6/Room 6H45, unless noted)

8:00-8:15 am	Opening Remarks – J. Feeley / W. Huntress
8:15-9:15am	Annual Ethics Briefing – A. Greenstone
<b>9:15-9:30am</b>	<b>Break</b>
9:30-10:30am	Status of HEO – W. Gerstenmaier <i>Joint Session with Human Exploration &amp; Operations Committee (HEOC)</i> Location: Program Review Center, Room 9H46; WebEx meeting: 991 759 074; password: @pril18athq; Call-in number 877.923.0445, pass code 1310790
10:30-11:00am	Joint Discussion Location: Program Review Center, Room 9H46; WebEx meeting: 991 759 074; password: @pril18athq; Call-in number 877.923.0445, pass code 1310790
<b>11:00-11:15am</b>	<b>Break</b>
11:15-11:55pm	Science Plan Objectives and Goals – D. Woods
<b>11:55-1:00pm</b>	<b>Lunch on Own</b>
1:00-2:00pm	FY14 Budget Overview – J. Grunsfeld
2:00-3:00pm	Planetary Science – J. Luhmann / J. Green
<b>3:15-3:30pm</b>	<b>Break</b>
3:30-4:30pm	Earth Science – B. Tapley / M. Freilich
4:30-5:00pm	Joint Agency Satellite Division -- M. Watkins
5:00-5:15pm	First Day Wrap-up – W. Huntress / J. Feeley
<b>5:15pm</b>	<b>Adjourn for the day</b>

NAC Science Committee  
November 14-15, 2012

Agenda  
(all times EASTERN)

Friday, April 19 (MIC-6/Room 6H45, unless noted)

8:30-8:40am	Opening Remarks/Announcements – J. Feeley / W. Huntress -- Talk Technology for next meeting
8:40-9:40am	Heliophysics – M. Hagan / J. Newmark
9:40-10:40am	Astrophysics – B. Peterson / P. Hertz
10:40-11:00am	JWST Status – G. Yoder
11:00-11:30am	Planetary Protection / PPS – G. Levy /C. Conley
11:30-12:00pm	Discussion with Associate Administrator for SMD – J. Grunsfeld
<b>12:00-1:00pm</b>	<b>Lunch on Own</b>
1:00-1:10pm	Public Comment
1:10-4:00 pm	Discussion, Findings and Recommendations
<b>4:00pm</b>	<b>Adjourn</b>

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