

NASA ADVISORY COUNCIL

SCIENCE COMMITTEE

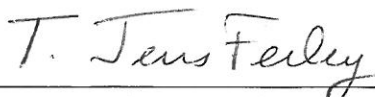
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NASA Headquarters
Washington, D.C.

MEETING REPORT



Wesley T. Huntress, Chair



T. Jens Feeley, Executive Secretary

Table of Contents

Welcome and Introduction	3
Science Mission Directorate (SMD)	4
Planetary Science Division (PSD)	7
Astrophysics Division (APD)	9
Heliophysics Division (HPD)	12
Earth Science Division (EDP)	14
Planetary Protection	16
James Webb Space Telescope (JWST)	18
Launch Services	19
Discussion with NAC Chair	20
Discussion of findings/recommendations	20

Appendix A- Attendees

Appendix B- Membership roster

Appendix C- Presentations

Appendix D- Agenda

Prepared by Joan M. Zimmermann

March 6, 2012

Welcome and Introduction

Dr. Wesley Huntress, Chair for the NASA Advisory Council (NAC) Science Committee (SC) opened the meeting, welcoming the new Acting Chair for the Heliophysics Subcommittee (HPS) Robert McPherron, and William McKinnon representing the Planetary Science Subcommittee (PSS). He welcomed Dr. Barbara Giles as the newly named as Director of the Heliophysics Division (HPD). Other changes include a newly appointed Chair for the NAC, Dr. Steven Squyres, an exceptional planetary scientist, and Chair of the Steering Committee for the National Research Council's 2011 Planetary Science Decadal Survey. Dr. John Grunsfeld has taken the place of Dr. Edward Weiler as Associate Administrator (AA) of the Science Mission Directorate (SMD). Dr. Grunsfeld is an astrophysicist and astronaut with great experience and knowledge in human spaceflight and robotic exploration. Noting that Dr. Weiler had retired abruptly in response to the FY13 budget, Dr. Huntress expressed regret at the loss of an effective AA, but was pleased to see Dr. Grunsfeld take the new position.

Dr. T. Jens Feeley made some logistical announcements, noting other changes in SMD. Dr. Paul Hertz is the new Astrophysics Division (APD) Director, and Mr. Michael Moore is the acting Deputy Director for APD. The SMD Chief Scientist position is currently vacant. The NAC charter has been renewed and the NAC will henceforth meet three times per year, so the Science Committee will follow suit (meeting again in the July and November timeframes). This year the SC Work Plan focuses on:

- Review and revise on rebalancing restructuring re: budget
- NASA strategies for response to the impending Heliophysics Decadal Survey
- Collaboration with international and interagency partners
- Cost-containment activities
- Lower cost of flight missions
- Earth and space science activities

Dr. Huntress expressed the committee's main concern, which was how NASA could fulfill its ambitious science goals given the reduced funding profiles contained in the President's FY13 budget request. Dr. Huntress said that for science, the FY13 budget contains welcome, but also appalling and discouraging news. It should be noted that NASA as an Agency escaped large cuts; the Agency's overall budget would sustain a less than one-percent reduction from FY12 under the President's request. For SMD the reduction was a bit less than 3 percent, and one must be grateful for the allotments for the Earth Science Division (ESD) and the James Webb Space Telescope (JWST). JWST is an agency priority and the Administration has largely accepted the re-plan for a JWST launch date of 2018. The bad news, however, is the flat science budget and the prohibition against Outer Planets (OP) mission planning. The Planetary Science Division (PSD) has been singled out for a 21 percent cut and a concomitant reduction in the outyears; the worst decline in 35 years. The Mars program, Discovery, New Frontiers, and operating

missions are all at risk. The 2016/2018 Mars opportunity partnership with the European Space Agency (ESA) has been abrogated.

Dr. Waleed Abdalati, NASA Chief Scientist, noted that Ed Weiler had fought for a different approach, but explained that the decision to cut the Mars program sprang from the risk associated with a number of major Agency commitments in the period around 2018, including commercial crew, the Space Launch System (SLS), and JWST. The second aspect was that ExoMars was viewed as putting NASA on a path to three flagship missions (three missions contained in plans for a Mars Sample Return mission) at a time when budget challenges would hardly allow one flagship. The cuts were not intended as malicious, but there were strong feelings all around. Dr. Huntress observed that the cuts hurt the entire PSD, not just Mars, but the budget action wrecks the Mars program and will hamper its recovery. Dr. Abdalati agreed with the Decadal Survey's conclusion about balance in the planetary program, and pointed out that there were directions in the Decadal Survey to de-scope flagships, to allow pacing of missions that are more commensurate with what the budget allows.

Science Mission Directorate (SMD)

Dr. Grunsfeld addressed the SC, speaking as a heliophysicist, astrophysicist, and former repairman for the Hubble Space Telescope (HST), and first thanked the committee for its efforts. He emphasized his great concern with the science enterprise of NASA, which he considered the greatest on the planet.

NASA Administrator Charles Bolden joined the meeting and briefly addressed the committee, acknowledging that there would be ups and downs in this budget atmosphere, which will require great assistance from the SC. He also asked the committee to consider themselves, as science ambassadors and urged them to reach out to the community, engaging neighbors, school groups, fellow faculty members, grad students, etc., and encouraging them to talk about the great science that NASA carries out. The public needs to know why NASA science is relevant to their lives.

SMD Budget

As special government employees, Dr. Grunsfeld also urged committee members to measure their public statements in order to send the message intended. Messages can be misunderstood by the public, and used as a headline out of context to damage the science program. Dr. Grunsfeld then discussed the guiding principles for SMD, which are driven by science, national needs and priorities; community involvement in program development; and transparency and openness in decision making. The budget strategy for FY13 will focus in continuing to provide the most productive science program possible within resource availability; managing the national investment in robotic space missions and closely managing JWST; planning and conducting a new Mars program with other NASA organizations to meet both human exploration and science goals; and adequately budgeting for launch services by NASA's Launch Services Program (LSP). NASA is looking forward to the arrival of Mars Science Laboratory at Mars in August 2012 and the launch of the Mars aeronomy mission (formally the Mars Atmosphere and Volatile Evolution or MAVEN) in late 2013. SMD hopes to have a stronger Mars program as a result of the re-planning now under way.

Overall, the SMD budget would be reduced from \$5.07B to \$4.911B from FY12 to FY13 in the President's request. One must remember these are taxpayer dollars, which support the third largest science portfolio in the nation. The Earth Science Division (ESD) is essentially flat. The "grey area" of the budget (2014-2017) chart denotes that the dollar amounts are notional, and the top line was kept constant. Overall the numbers will be adjusted to achieve the flat top line, but NASA will not know what the distribution will be until the President presents the next budget request (for FY14) in February 2013. Budgets are essentially flat, with the exception of JWST. It must be remembered that NASA will need commercial re-supply to the International Space Station (ISS) and commercial crew support, and a heavy-lift rocket with a large fairing, which will allow future flagship missions. The planetary science cut is considerable; the normal ramping down of funds after MSL and MAVEN launch is commensurate with the proposed out year reductions in the planetary program. SMD is trying to avoid a "flagship bubble" that could potentially produce overruns and ruin the entire program. Within the New Frontiers program, the OSIRIS-REx mission has been selected; this mission, formally called Origins-Spectral Interpretation-Resource Identification-Security-Regolith Explorer, will be the first U.S. mission to carry samples from an asteroid back to Earth. The Outer Planets program is confined to studies. The Nuclear Spectroscopic Telescope Array (NuSTAR) is an Explorer mission that will allow astronomers to study the universe in high energy X-rays and it is currently scheduled for a March 2012 launch aboard a Pegasus launch vehicle. JWST has the baseline funding it needs to launch in 2018.

Recent highlights in SMD include the provision of a letter to European Space Agency (ESA) to request participation in ESA's Euclid Dark Energy mission, for which NASA will provide infrared detectors. The Balloon Research and Analysis (R&A) program has been held flat to address other priorities. Explorers will be down-selected in 2013, and SOFIA continues development and early science flights. The Hubble Space Telescope (HST), Chandra, Fermi, Kepler and other operating astrophysics missions will be subject to a Senior Review in 2012. The Keck Interferometer will cease NASA-sponsored operations, as planned, in 2012. Within PSD, the division will be closing out the 2016 and 2018 Mars missions, but will bring the instruments to Preliminary Design Review (PDR) level so that they are ready for future opportunities. MESSENGER is continuing its observation of Mercury from a lower orbit; and the lunar GRAIL mission is now taking science data. The Lunar Atmosphere and Dust Environment Explorer (LADEE) and MAVEN launches are due in 2013. SMD will continue with R&A selections and awards. ESD is still seeking an alternate launch vehicle for the next orbiting carbon observatory, OCO-2 and for SMAP and Jason-3.

SMD's Heliophysics Division (HPD) is working on a new Peregrine motor to replace/augment its Black Brant motors in the Suborbital Program, and is maintaining its current balloon program. ESD has many missions in development. Juno and GRAIL both launched on schedule and beat their budget commitments; these successes have shown that NASA is using predictive tools to good effect. SMD is also increasing its cooperation with human exploration endeavors at NASA. Dr. Grunsfeld noted the 2011 Nobel Prize in Physics was largely based on HST observations regarding the accelerated expansion of universe.

Science highlights include recent satellite measurements that have detected and diagnosed a 5mm sea level drop in 2011 (Topex/Poseidon and Jason 1 & 2 data), within a global mean trend of a 3.2mm/year sea-level rise. The drop, supported by measurements from the Tropical Rainfall Measurement Mission, is

attributed to the climatic transition from El Niño to La Niña caused rainfall rates to change significantly between over land and over ocean areas. GRACE has observed a mass loss over the oceans and has seen mass anomalies consistent with a higher than normal concentrations of ground water in South America and Australia and lower than normal precipitation over the open oceans; the drop in sea-level rise could be explained by these data. The moisture currently observed in ground water will flow back out eventually, such that researcher should be able to predict a resurgence of sea-level rises when the cycle recommences.

Aura/OMI measurements have shown distinct enhancements in NO₂ and SO₂ concentrations over Canadian oil sands. A huge concentration of these gases are sitting right over the tar sands, equivalent to the output of a power plant of a moderately-sized city. The Solar Dynamic Orbiter (SDO) detected a major coronal mass ejection (CME) coming toward Earth in late February. The Mars Reconnaissance Orbiter (MRO) has provided evidence of briny liquid water flowing downhill, bolstering the theory that Mars has a current hydrological cycle that is more widespread than previously thought. The brines are likely some ancient water, and have been seen in 6 different locations. (Liquid at very low pressures and temperatures are indicators of brine). The Spitzer space telescope (operating now without cryogenics in its 'warm' phase) has revealed a carbon-rich planet through the viewing of an exoplanet transit; discoveries such as this should be commonplace when JWST launches in 2018.

Administrator Bolden made some further remarks asking, that as the Agency goes through the next few months of churn, for the Science Committee to be critical but helpful; the ExoMars program is a great example of a problem that needs to be understood. He asked that the community re-consider the concept of flagship missions, as they are bold and risky and bring about great discoveries. However, under current budgetary constraints, flagships must be viewed in a different light (not just determined by an expected cost of \$1B or more).

The current NASA efforts to develop the Space Launch System (SLS) and the Multi-Purpose Crew Vehicle (MPCV) are flagship missions, in fact.

Dr. Eugene Levy commented that from his perspective, a flagship is a mission with a scope of ambition that sets it apart, which usually has implications for cost and complexity; international collaboration between agencies should be strategic. To date, NASA has not been able to effectively achieve this collaboration with ESA. The changes in the Mars program have dealt another blow to this effort.

Mr. Bolden emphasized that NASA has not withdrawn from the Mars program. The Agency still maintains collaboration with ESA; but he has asked for a strategy for re-engagement on Mars mission. ESA is waiting and willing to sit down with NASA to fulfill what ExoMars was meant to do, and also to get humans to Mars in the 2030s. ExoMars was originally a 2016 mission/relay orbiter, with the launch vehicle provided by NASA. It soon became evident that the envisioned mission was not possible within the budget, the primary issue being the costs of providing a launch vehicle. The two agencies discussed combining the 2016/2018 opportunity, but the European industry/ESA decided that this was a nonstarter. Given the changing budget environment, NASA cannot provide a 2018 caching lander along the lines of the flagship Mars mission described in the Planetary Decadal Survey. The original statement of intent only focused on collaboration at the study level. The science community has not gotten that message.

Dr. Grunsfeld added that JWST had been designed up front as an international program, including 2 instruments from ESA, and a fine guidance sensor (FGS) from Canada. ISS has also shown NASA lessons on international relations. Mr. Bolden averred that in developing the 2013 budget, it became clear that Mars missions could not be carried out as originally envisioned, but there is no intent to prohibit the future of the Mars program. He felt that Congress would understand that this is a serious situation and would act appropriately. Dr. McKinnon felt that the loss of the ExoMars mission was a big blow to the spirit of ESA cooperation. Mr. Bolden agreed that while ESA is obviously nervous, the agency heads consider themselves as friends, and the involved nations have common objectives. ESA's Director General was pleased with the outcome of NASA's entire budget request (\$17B), and with hearing NASA say that it is NOT walking away from Mars and robotic exploration, and that humans at Mars in the 2030s is still a goal. International cooperation is difficult; NASA and ESA both recognize this. Dr. Hinners commented that the originally conceived Mars sample return campaign was spread out to keep costs and risks down; the plan was a deliberate strategy. Mr. Bolden agreed with the strategic thinking, and suggested that if NASA were to plan a human mission in the 2030s, then it made sense to use the 2018/2020 opportunities to launch a catcher (the next best opportunity after 2018/20 is in 2034). It is important to make this 2018/20 opportunity. Most scientists support the concept of achieving a sample return prior to achieving human return.

Dr. Alan Boss, Chair of the Astrophysics Subcommittee (APS), commented that given ExoMars is the highest priority of the Decadal Survey, a mid-decade review would be necessary. Dr. Grunsfeld responded that the framework for the longer-term program of Mars exploration includes both science and humans; he anticipated that mid-decade would be the time to return to the survey, or to commission a special study. The Decadal Survey has already laid out the science; NASA must still work within the budget constraints while responding to Decadal Survey priorities. Dr. Boss was inclined to have APD revisit its Survey priorities on a similar timetable. Professor Scott Hubbard asked how the Human Exploration and Operations Mission Directorate (HEOMD) and the Office of the Chief Technologist (OCT) might contribute brainpower and resources to Mars. Dr. Grunsfeld responded that those groups will not be transferring funds across lines; the broader perspective is to combine efforts in a high-level philosophy and the specifics will be worked out via Orlando Figueroa's new Mars review team. After his team's assessment, SMD will have some sort of idea of what will be possible in a 2018 mission. ISS is providing some data that is relevant to humans on Mars, such as the effects of six months of weightlessness (but no radiation monitors). The new Mars team will receive input from the community, an analysis group chartered by MEPAG (precursor SAG), and academia; most communication will take place by telecom/Webex, and face-to-face meetings at Headquarters.

PSD Update

PSD Director Jim Green provided an update, first reviewing the Year of the Solar System planetary science mission events, including the successful launch of Juno to Jupiter; GRAIL A and B are orbiting the Moon, Dawn will be visiting the asteroid Ceres this summer, and MSL is scheduled to land on Mars in August 2012. A fourth-grade class in Montana submitted the winning names in a national competition, so the Grail A and B spacecraft are now known as "Ebb" and "Flow". The science phase has begun for Grail, and its communication links are working perfectly. LADEE and MAVEN have successfully completed their Critical Design Reviews (CDRs). PSD has selected 3 Discovery missions for study: a

comet lander/hopper, a Mars Lander, and a Titan boat. Selection will take place in early summer 2012. PSD has also selected as its New Frontiers mission the OSIRIS-REx asteroid sample return mission. Operating missions have continued to make great discoveries. The HiRise instrument on MRO has measured the wind speeds of Mars dust devils. The Opportunity rover currently sits at the Greeley Haven section of the Endeavor crater, and is sending signals back to Earth allowing us to study the gravitational effects on the signal. Dawn observations of Vesta's giant impact craters have revealed a large peak, 20-25 km in height. Dawn has also confirmed presence of a core in Vesta, indicating that it might have once been a planetesimal. Cassini has been sending images of an enormous storm on Saturn, larger than the continental US, characterized by intense lightning bolts.

PSD has initiated a new Mars strategy, partnering with OCT and HEOMD, looking at a 2018/20 opportunity, and finishing out work on the 2016/18 missions. The Lunar Quest program will be phased out after LADEE. The Discovery flight rate has been reduced (the next AO has been moved to FY15) and New Frontiers has been slipped a year (next AO in FY16). Dr. Huntress commented that these latter plans fly in the face of the Decadal Survey. The Near Earth Object (NEO) program has been expanded to increase detection and characterization efforts. Operating missions remain the same. New Advanced Stirling Radioisotope Generators (ASRGs) continue in development, and the division is maintaining navigation and sample curation elements.

Planetary R&A is relatively stable. A sum of \$2M will be provided to NSF for support at Arecibo in imaging NEOs. PSD has four instruments on ESA's Rosetta mission, and is also supporting a call to examine Hayabusa samples. Future budgetary lines must also take into account the cost of launch vehicles.. The status of MSL and the Mars rovers will be determined in the future through the Senior Review process- each mission only carries funding for its own mission; the rest goes into a pool. PSD recognizes that the budget is very short in FY13-15. There are adjustments that need to be made. The rest of the operating missions are bookkept in Discovery and New Frontiers and should be OK. Operationally, the biggest problem is in the Mars area.

In Outer Planets (OP), there is sufficient money to operate Cassini throughout its extended mission (EM). The planetary flagship line has a planning wedge for studies only; OP is considered notional. Dr. David McComas commented that in HPD, missions commonly get reduced with each Senior Review. Dr. Green added that Cassini has already had two Ems with a 25% operations cost reduction, and is now also looking at potentially another reduced funding level. Dr. McKinnon voiced concern for the future of the OP line, as Cassini will be deorbiting in 2017, possibly signifying the end of OP missions since Juno will de-orbit in the same year.

PSD will continue to work on ASRGs and with DOE on the re-start of domestic plutonium production; NASA may have to bear the sole cost of the re-start, and will have to slow down significantly or increase funding. As for ASRG units, both the Titan boat and comet hopper will have them when needed. If they are not selected, the ASRG will continue to be developed and will simply look for another flight opportunity. A launch vehicle for OSIRIS-REx has not yet been determined, but a budget has been put aside for it.

Planned accomplishments for PSD at present are the successful landing of MSL/Curiosity on Mars, Dawn breaking orbit to move to Ceres, LADEE and MAVEN will move into their final development phases.

ASRG will complete development, the DOE plutonium re-start study will complete its report; PSD will conduct two-year cycle Senior Reviews for many missions, will accelerate the NEO program with enhanced funding, and will continue the R&A program

Planetary Science Division (PSD)

Dr. Bill McKinnon, standing in for Acting Chair Jim Bell, reported on PSS's view of the latest budgetary changes. PSS held a teleconference immediately after the budget release to discuss the critical issues for PSD, which is the loss of flagships as comprehensive, transformative, and paradigm-changing missions. PSS is very concerned about the damage to international relations and the seeming lack of funding for ongoing planetary missions. The Discovery program cadence of announcements has been delayed so that it will now be about 54-months between opportunities, and New Frontiers has been delayed as well. Will there be sufficient investment in technology to enable future missions, and R&A stability if the flight rate attenuates? The last Mars Exploration Program Analysis Group (MEPAG) meeting took place in late February; it was very large and well-attended; a letter report from this meeting was sent to Jim Bell yesterday.

The Planetary Decadal Survey illustrates why this budget seems like such a step backward. This particular Decadal Survey had been responsive to cost concerns up front. The Survey had called for Planetary R&A to be maintained at a healthy level, plans for 2 New Frontiers missions within the decade, a 24-month Discovery cadence, development of a Mars flagship 2018 mission with ESA and as first stage of Mars Sample Return; initiation of a study for de-scoped Jupiter Europa Orbiter (JEO) for possible implementation as funds allow. Instead, the real planetary budget has effectively dropped 21% from FY12 to FY13. Programmatic impacts are numerous: significant delays in Discovery/New Frontiers program, no future missions to OP or specific plans to collaborate with ESA in a mission such as JUICE/LaPlace, and the loss of the Mars 2016/18 missions. Operating missions such as Curiosity and current missions are in jeopardy.

At this time, the outlook for the Mars program is poor. MEPAG has expressed its distress and views the cuts as a grave threat to the existence of the Mars Exploration Program, and is assembling an Analysis Group to address and analyze concepts and strategies for potential SMD-HEOMD Mars objectives. PSS fears that technology and capabilities will be lost if NASA does not take advantage of the celestial mechanics that are imminently favorable for Mars, and which will not return until 2034. The runout of the Cassini Solstice mission has been reduced, and there is no plan for a Program Scientist or instrument support for the ESA Laplace mission. At present there is no evidence that a flagship can be done for less than \$1B. Dr. Green noted that the only way a new flagship could be accommodated is through a new start; NASA is delivering 3 studies to Congress to determine this. A Europa Science Definition Team (SDT) studied what a de-scoped mission could do; splitting the mission into an orbiter and multiple fly-by has been suggested. These two concepts have been independently reviewed. A lander for Europa is also under study. These all will be cheaper than JEO, which was costed at \$4.7B. Dr. McKinnon's personal view was that these flagships tend to blossom in cost, and that past approaches have been far too ambitious. Professor Hubbard commented that a big part of extra cost in past missions lay in the assessment that projects had skimmed on margins, which they had assumed would be added back. In the

two studies completed thus far, the teams are addressing margins up front while trying to recapture a good deal of Decadal Survey intent.

Dr. McKinnon brought forth Dr. Jim Bell's personal assessment of compliance with the Decadal Survey. Dr. McKinnon carefully noted Dr. Bell's opinion has not yet been fully vetted by PSS. There was a mid-term review of the last Decadal Survey, thus one can expect a re-assessment in 2017, and can use the FY14-17 budget to predict the scorecard. In a letter grade rubric as defined by NRC, with trends, Dr. Bell's projection for 2017 is looking grim: D for technology development, trending down; D for missions in flight, trending down; B for R&A, trending down; C for missions in development, flat trend; F in Flagship missions, flat; F for E/PO, flat; and Fs for both Discovery and New Frontiers, flat trend.

In summary, for PSD, it has been an incredible year of mission and scientific accomplishments. PSD has demonstrated the ability to operate missions for years at a time, at a giant planet far from the Sun, and has landed successfully on Mars 6 times. Planetary science appears to be a very low priority in the Agency despite being the "crown jewel" of the Agency. The committee briefly discussed the favorable dynamics for Mars that is partly driving the discussion for mission opportunities, and which considerably influence the amount of mass that can be carried for a mission. Professor Hubbard noted that the same 15-year pattern occurred in 2003, which was why rovers were recommended at that time; the difference between 2003 and 2005 were "day and night." Dr. Eugenia Kalnay expressed astonishment that current Mars assets cannot be improved. Dr. Huntress asked that the Science Committee be kept apprised of the situation and looked forward to a first briefing by the end of March. Dr. Grunsfeld emphasized that the team should wrap up in August, allowing for submittal into the FY14 budget submission. Dr. McKinnon observed that PSD seems to be looking at a strategic mission to Mars at a cost of New Frontiers mission.

Astrophysics Division (APD)

Dr. Paul Hertz, newly appointed Director for APD, began the division update with science results from the Kepler mission. Kepler has discovered Kepler 20e and Kepler 20f, the smallest exoplanets to date (Earth-sized), as well as systems with multiple planets and systems with planets in the habitable zone. HST has revealed a new class of extrasolar planet, a water world, smaller than Uranus but larger than Earth. Warm Spitzer has discovered buckyballs (buckminsterfullerene carbon forms) in space around a pair of stars called XX Ophiuchi. This predicted discovery was another milestone in the study of organics and prebiotic molecules in space.

Missions in formulation for APD are mostly green. NuSTAR is yellow largely due to launch vehicle issues. NuSTAR is a Pegasus launch with first-use avionics. Astro-H is yellow for cost, integration and schedule challenge; NASA has been working with the Japanese to accommodate impacts to the development plan due to the March 11, 2011, tsunami. SOFIA successfully completed 45 flights during the early science phase, including GIs and guaranteed time. SOFIA is now in planned downtime as additional platform capabilities are taken on. At the moment, SOFIA meets Level 1 requirements for imaging and pointing, but the mission will seek to reduce jitter to improve image quality. Active mass dampers have been added to reduce the jitter. Meanwhile SOFIA is behaving according to original specifications.

Astro-H is shipping engineering models to Japan and has passed mission CDR. NuSTAR has been mated to the Pegasus vehicle and the fairing has been installed; it will soon be mated to the aircraft and ferried out to the Kwajalein facility. GEMS (an x-ray polarimeter mission) is in development for launch in 2014, having just passed its PDRs, and is on its way to CDR in April. Kepler continues to produce high-value, high-quality science, and continues to release data. In the Kepler extended mission, there will be no period of exclusive data use (a.k.a. proprietary data time.). APD is maintaining a robust Suborbital program. CIBER was waived off because of winds at altitude and will try again next month. Two successful ballooning campaigns were carried out in Antarctica, and more balloons are being readied for a Swedish and a Southern Hemisphere campaign. Operating missions are green, and GALEX is in stand-by mode. APD just completed a Senior Review of all operating missions; a report will be available at the end of March. Concerning Euclid, ESA is interested in a NASA partnership. The NRC has reviewed the partnership opportunity, and there have been positive responses all round. The mission supports Decadal Survey science priorities, and NASA's hardware contribution of \$20-30M (near-IR detectors) is reasonable (but no substitute for WFIRST). NASA has informed ESA that the Agency is willing to go forward. NASA scientists for Euclid will be chosen in an open call through ROSES.

Budget

The budget for NASA's astrophysics investments includes both the APD budget and the JWST budget. JWST is taking up a good amount of the NASA astrophysics budget; the President has proposed spending \$1.3B next year on astrophysics, rising to \$1.35B over the next couple of years. The challenge is the notional runout, which will force the division to back down on activities previously planned. APD has a pretty good plan in place for accommodating FY13; the division will be reducing the amount spent on competed technology calls, will not be increasing some R&A programs as previously planned, will defer some mission concept studies, and must also make accommodations for the increased costs of GEMS and the recommendations of the Senior Review. Astro-H and GEMS budget profiles have also changed. It is known that GEMS will be coming in at 10% over the cost cap, and APD must set aside reserves to bring confidence level to 70%. APD is also getting resources ready to support the Euclid partnership, is deferring increases in the Suborbital program, and is delaying the launch of the next Explorer by one year.

SOFIA continues its development plan, the Keck Interferometer will cease operations as planned, and a Senior Review will be held for HST, Chandra, Spitzer, Fermi, Kepler and other operating missions. In the Explorers program, the first priority will be to complete Explorers in development. APD will release a mission of opportunity (MO)-only call this Fall, and then go forward with a full mission and another MO. WFIRST's Science Definition Team (SDT) completed its first design reference mission (DRM) last year (with full realization of science objectives), and will complete a second DRM to explicitly take into account other assets available (LSST, JWST, Euclid). Through the SDT, APD will continue to establish a basis for WFIRST. Mid-decade, APD will determine whether proceeding with WFIRST is still a high-priority mission given the late launch date. Last year, the division was able to achieve 10% growth in R&A; however, since the new budget was released, the balance in the program must be re-assessed.

In terms of responding to the Decadal Survey, given the President's budget request, Dr. Hertz noted that there is no request for a new start of a large mission throughout SMD. The current budget allocates \$880M over the decade (not including JWST.) to Decadal Survey priorities, compared to the \$3.7B that

the Decadal Survey recommended and prioritized. APD is following the Decadal Survey recommendations under the constrained budget as written: preparing for WFIRST, augmenting R&A and Explorers, and making “down payments” on augmenting the core research program. The division is working with program offices to develop a rebalanced plan to respond to this notional budget runout, and expects the NRC to comment in the CAA and the mid-decade review on NASA’s balance on working toward 5 large missions for the next Decadal Survey, while realizing the science of WFIRST and Astro2010. There is a very vigorous set of advisory groups working on this activity, it will be important to bring real, implementable options within the budget request. Dr. Hinners commented that it seemed early in the process for GEMS to exceed its cap. Dr. Hertz attributed the overrun to technology development taking longer than planned and loose management during phase B.

Astrophysics Subcommittee (APS)

Dr. Boss, Chair of the Astrophysics Subcommittee (APS) presented the view of the APS via its latest recommendations. APS is grateful to both the Administration and Congress for its support of JWST, which was the top priority of the 2001 Decadal Survey. APS and the NRC fully endorse the decision to join the Euclid Dark Energy mission by providing detectors and supporting a US science team, at the cost of about \$50M over the next 15 years. Professor Hubbard asked whether any insight had been obtained on ESA’s reaction to NASA’s partnership offer. Dr. Hertz explained that ESA has indicated a positive response. ESA has had to re-plan an ESA-only version of Euclid, realizing that it cannot achieve the mission size possible within a full partnership. NASA is doing something that ESA was going to do itself. NASA will be joining ESA later than is customary in a normal partnership. There is also another opportunity to partner on ESA’s future M- and L-class missions. Dr. Boss added that the APS has encouraged NASA to take advantage of these opportunities. The APS has also encouraged NASA to revisit the budget limits and launch capabilities of the Explorer program, including in the study the impact of a reduced mission cadence. The APS also recommends that NASA charge the mid-decadal review according to a reassessed view of how science priorities are carried out, tactically.

The APS is concerned about the budgetary climate and its severe constraints on realizing major missions called for by Astro2010. APS recommends that APD balance proposal pressure across the R&A program, to help improve success rates. The APS regrets the 30% cut in non-mission E/PO and urges that competitive EPO programs (EPOESS within ROSES) be re-instituted in future years at the level of FY11 funding.

Dr. Boss offered a report card projected for the mid-decade review. WFIRST will not be achieved, nor will the LISA and IXO missions. There will be some Explorer augmentation, but no Inflation Probe technology development. New Worlds technology has been deferred but may earn a B-minus. There are no significant Astrophysics Theory or Suborbital Program augmentations. A JAXA-led SPICA mission and intermediate technology development is to be determined. APD will earn an A for development of UV/optical space capability. It may be possible to realize progress in the Theory and Computation Network. Professor Hubbard commented that there has been fanfare about next generation Suborbital researchers, however no connection has been made thus far. Dr. Hertz commented that Suborbital calls in ROSES are fully open for any payload; one may propose payloads for nontraditional platforms such as ISS, next generation commercial systems, and cubesats. This peer-reviewed call has been available for 2

years, but little response has been seen. Dr. Abdalati noted that the nontraditional platform effort is getting most of its traction thru HEOMD for microgravity-related experiments; the Space Technology Program makes use of these programs. Dr. Hinnners asked if JWST costs would further imperil the APD. Dr. Hertz assumed that JWST problems would be dealt with at Agency level.

Heliophysics Division (HPD)

Dr. Barbara Giles, Director of the Heliophysics Division (HPD) reported on the status of the division. Within the flight program, the Magnetospheric Multiscale (MMS) mission set for late 2014 is coming along well. The Radiation Belt Storm Probes (RBSP) mission is on schedule for a September 2012 launch and is currently finishing thermal vacuum testing. SET, a small payload piggybacked on a Defense Meteorological Satellite Program (DMSP) mission, has been postponed to 2014 (but has been delivered and is waiting for launch). Solar Orbiter (SO) and Solar Probe Plus (SPP) are both in phase B at this point. HPD is working out instrument delivery to ESA for SO and will be providing the launch vehicle. SO will reach PDR next month. SPP is entering a two-year phase B, during which the mission will work on retiring risk. The Image Reversal in Space (IRIS) Explorer mission is working toward a June 2013 launch date. For future Explorer missions, HPD has not scheduled a new AO; the next call will likely occur in Fall 2012 or Winter 2013. HPD is maintaining a robust Suborbital program, and will be carrying out mission called ATREX during 14-15 March, launching 5 rockets into Earth's ionosphere out from the Wallops Island facility. The Heliophysics Systems Observatory is comprised of 17 healthy spacecraft at present. HPD will hold a Senior Review in 2012.

Major recent accomplishments include 3-D images of solar flares and CMEs from the Solar Dynamic Observatory and STEREO. Spacecraft recently tracked a solar storm from Sun to Earth, discovered magnetic "bubbles" at the edge of the Solar System. The division has also developed a new Interplanetary Space Weather forecasting system, working with NSF, DOD and NOAA. Major flight accomplishments include a completed CDR for IRIS, engineering test units successfully completed for MMS, and a second BARREL test campaign in the Antarctic, delivering the first of 40 balloon flight payloads.

Budget

Within the new budget parameters, HPD has accommodated increased Atlas LV costs, and has made a modest investment in the Sounding Rocket sustainer motor activity. The division is continuing to fund operating missions, and is maintaining suborbital and research programs at their current level. The top line in HPD saw a slight increase, which, however, already had liens. The research side is flat, but there has been some increase in the Sounding Rocket program to cover technology needs and new motors. Within the Living with a Star (LWS) program, the RBSP budget goes down, but SPP gets ramped up. There is very little budget for the future missions line at this point. The Explorer program is decreasing, reflecting the flight of IRIS, but will ramp up in future for new Explorers. APD has been encouraged to select one full mission and one mission of opportunity, and will work toward it. The next Explorer AO is to be determined, depending on what is selected in Spring 2013. HPD, in outyears, is a bit lower than APD. HPD hopes to plan the next Solar Terrestrial Probe (STP) mission when the Decadal Survey comes out in April 2012. Planned accomplishments of note: HPD does plan to retire technology risks associated

with SO and SPP before they are transitioned into development. Both of these missions must come within their commitment to fit into the budget profile. A new multi-agency Memorandum of Understanding (MOU) has been signed to create a Unified Space Weather Capability. Dr. Huntress asked what sort of fiscal guidance had been given to the upcoming Heliophysics Decadal Survey. Dr. Giles replied that projected costs had been based on FY12, with the outyears slightly different, but consistent overall with the FY13 budget. Dr. Hinnert asked if there had been any discussion with HEOMD on their needs downstream on information for solar weather. Dr. Giles explained that HPD is well integrated with the space weather councils and committees, as well as with members of the OCT. The division is also involved in the Space Radiation Working Group. Dr. Giles agreed to report on the space weather activity at the next meeting; Dennis Gallagher took an action to place the report on a future agenda. Asked where the MOU led programmatically, Dr. Giles noted that the MOU does not compel more work; it simply paves the way for better coordination among agencies. HPD would also like to see a more unified method applied from research to operations and research to applications, an effort which would need a new funding wedge; this could put more effort into funding people in model development to transition models to operations more quickly, emulating Earth Science models for space weather.

Dr. Robert McPherron, acting Chair of the Heliophysics Subcommittee (HPS) provided an overview of recent subcommittee discussion, highlighting science accomplishments within HPD, and noting that the heliophysics community has long been engaged in speculation about the effects of another Carrington event, and has been trying to convince the government to study this possibility, as well as other low-level, widely felt impacts of sun energy. The subcommittee developed a finding concerning the importance of NASA's open data policy. HPD also called for an assessment of the success of NASA's open data policy, as well as a method for solving problems in creating uniform data access, and encouraging metadata production and use, as well as encouraging common format standards and handling large data volumes. This assessment would also require model-data comparisons and insights.

HPS also heard about E/PO's cut, an overall \$4M reduction in a \$16M program, signifying that E/PO was not competed this year. E/PO mission support continues at 1%, however. HPS heard a DSCVR mission briefing, a mission which is now in progress with NOAA. HPS is also convening a committee to help convert Decadal Survey into Heliophysics Roadmap terms to help HPD implement recommendations consistent with NASA resources and objectives. HPS was also informed of continuing changes in R&A solicitations, including a mandatory notice of intent (NOI) to be provided two months in advance of proposal submissions; this change is intended to move the review process forward. GI proposals will be solicited at the same time, to address the goals of a specific mission. The new structure is aimed at making it difficult to recycle proposals, and to make specific AOs more distinct.

The Geospace MOWG report expressed concerns about the TIMED and RBSP missions. GMOWG supports the newly introduced ROSES proposal changes and is continuing to evaluate the possibility of further changes, including a downselection in the first step of a two-step process. The Space and Heliophysics MOWG (SHMOWG) also similarly endorsed the changes in the proposal process, but expressed more concern about the consequences of future changes. SHMOWG was particularly worried about the decline in R&A funding/proposal pressure; as well as support for ground-based systems and the infrastructure needed for development and calibration of space instrumentation. HPS heard some interesting observations about space weather from Dr. Karel Schrijver, who speculates that the US may be

taking the wrong approach in its focus on the more extreme effects of solar activity. Dr. Schrijver suggested that the cost of everyday disturbances in the North American power grid, costing up to 4B per year, should be more closely studied. These low-grade disturbances appear to be positively correlated with x-class flares, and the observations need to be clarified. Earth systems are more and more interconnected and therefore becoming more susceptible to space weather. HPS also noted the setup of the Space Weather Working Group.

Requests for future input to HPS include a briefing on launch services (e.g., how frequently new launch classes are introduced and how rapidly NASA can respond), and the coordination status between OCT and HPD, as well as more information on the two-step proposal process. HPS had one formal finding on data policy, encouraging an open data policy on both sides of an agreement between NASA and other agencies, and another on the redefinition of the proposal process. Dr. Huntress felt these HPS findings were appropriate for SMD. The committee briefly discussed the 2014 timing of DSCVR and the space weather MOU, and requested more information on how the MOU was coordinated, and among which centers and agencies.

Earth Science Division (ESD)

Dr. Byron Tapley, Chair of the Earth Science Subcommittee (ESS), reported that the subcommittee has not had a formal meeting yet this year, but had heard a budget briefing during a recent teleconference. ESS will meet formally on 21-22 March; the agenda will include JPSS, LV discussion, ESD ground networks, and the modeling and satellite simulation program. Launch vehicle cost concerns persist while reliability decreases and the availability of launch vehicles is decreasing. This state of affairs has impacted scientific yield (e.g., Glory and OCO failures, representing a loss of \$1B in science yield). The community recognizes that international collaboration is key to future success in observation strategies; ESD has been successful in accomplishing this collaboration. The science community is concerned about how an overall strategy for input into the Decadal Survey will come about.

The ESD program calls for launching 10 satellites through 2020, while the budget calls for some reduction in scope; there is an ongoing concern about keeping existing measurements, as the current satellite suite is aging. Continuity of measurements for assessing climate change remains a concern. Interagency and international collaboration will be necessary to accomplish this. GRACE will be in orbit for ten years on March 17, 2012; this spacecraft has provided important measurements of global sea level change.

Budget

Dr. Michael Freilich, Director of ESD, continued the presentation with a status of the division, focusing on the programmatic impacts of budget. Two recent positive results include the successful June launch of Aquarius on a Delta II. Aquarius measures sea surface salinity, closing the hydrologic loop. Standard data have been produced since late August. Salinity is measured via the change in dielectric properties at low microwave frequencies- at about 1 GigaHtz, sea salinity is the biggest contributor to microwave return. Aquarius also flies an L-band scatterometer to measure sea surface roughness. NPP launched on 28 October 2011. Suomi NPP is a joint NASA/NOAA/DOD pathfinder mission for polar-orbiting meteorological satellites. The NPP spacecraft name has been changed to honor Vern Suomi, and NPP

now stands for National Polar-Orbiting Partnership. Validation of Suomi NPP will continue for another 12-15 months, then operations will transfer fully to NOAA. NASA supplied the CERES and ATMS instruments, and paid for a portion of OMPS (Earth “radiation budget” instrument, microwave sounder, and ozone mapper, respectively.); NASA also funded and implemented the spacecraft and launch vehicle. There are 14 other operating missions in ESD, (a total of 16 with Suomi-NPP and Aquarius/SAC-D), many with international partnerships. There is also strategic collaboration among international agencies to form a virtual observatory., through constellation flying in the presently 5-mission A-train.

ESD operating missions recently underwent a Senior Review, which took into consideration national needs and technical/cost considerations, in addition to the science evaluation. All presently on-orbit extended missions were recommended and approved by the Division for continuation, including ACRIMSAT. Addressing the budget, Dr. Freilich noted that the President’s budget request called for FY13 \$1.785B for ESD. Two key points about FY13 are: 1) there is some level of stability in the Administration for ESD support, as the outyear budgets in the FY13 request are nearly identical to those same years in the FY12 budget request; in FY12, the Congressional appropriation was negligibly different from the budget request. However the appropriation is still significantly below Decadal Survey assumptions, and only slightly above the FY09 level. FY13 is about \$25M above the FY12 appropriated level. The second point, 2), is that there have been internal pressures on the budget; the loss of the Glory mission owing to a second consecutive launch vehicle failure on an ESD mission has put near-term pressure on funding, particularly in the area of higher cost, more reliable LVs. ESD has had to carve out \$250M in FY12-15 for increased LV costs and mission delays for OCO-2 and SMAP. Over the last 5 years, ESD has lost about \$1B in mission costs and redesign/delay activities, but the division has absorbed this loss and is moving forward. A solicitation for multiple launch services for OCO-2 (NET July 2014), Soil Moisture Active Passive (SMAP; October 2014), and JPSS-1 has been released, with a higher evaluation emphasis on reliability. Some small decreases will be seen in R&A, Applied Sciences, and Technology. All three strands of the Venture class missions are fully funded in the current budget. Asked about failure review reports on the Taurus XLs, which caused both OCO-2 and Glory mishaps, Dr. Freilich reported that neither report found a root cause for the failure (Glory’s report is not yet public, but has been confirmed to contain no root cause).

The program and budget strategy for advancing Earth System science must rely on collaboration. Dr. Freilich reported holding leadership positions on two committees that cover both interagency and international collaborations in order to facilitate working relationships. While the Decadal Survey is a key document, ESD also must consider administration priorities and national needs, as well as the opinions of OSTP, USGCRP (representing 13 agencies), and OMB. The Decadal Survey called for an increased budget, but the Climate Architecture document has been able to work within budget constraints and the needs across the federal agencies. It must be noted that the Earth Science Decadal Survey was directed to NASA, USGS, and NOAA; NASA had the biggest fraction of the portfolio. There was little input from the commercial arena, except for high-resolution imagery; no one has been able to make a commercial business plan in the moderate-resolution ranges.

In terms of mission timelines, the Landsat follow-on mission (LDCM), a joint mission with USGS, is on track to launch in January 2013; GPM, a joint mission with the Japanese space agency, in February 2014;

OCO-2 in 2014; GRACE-FO, a joint mission with German agencies, in 2017; ICESat II in January 2016; SAGE III on ISS in August 2014, and SMAP in October 2014. The Venture-class program, representing a competitive, science-driven, PI-led class of orbital and suborbital missions to complement systematic missions is fully funded in three “strands”: EV-1, an airborne suborbital mission solicitation, selected 5 separate investigations. EV-2 had a solicitation in September 2011, for a small complete mission for under \$150M or a small standalone payload on a MOO.; these proposals are presently under review. The EV-Instrument call is for spaceborne instruments to be flown on a MoO; proposals for EV-Instrument are due May 2012. NASA will help find flights for these instruments.

Dr. Freilich felt that the key to ESD success for Venture-class will be to keep missions inside the box via hard-nosed and uncompromising management; if costs are well managed, new solicitations can keep going out on schedule. Dr. McComas commented that instruments are often driven by the launch environment and asked how ESD planned to deal with this aspect of development. Dr. Freilich replied that ESD has established a common instrument interface study to provide the outlines of instrument specifications in terms of mass, power, and data. The instruments will be built to accommodate conditions. Dr. Kalnay asked if there might be any hope for WIND (solar wind observer) and AIRS (infrared sounder) types of measurements. Dr. Freilich felt, that if the CRiS instrument operates as hoped on Suomi NPP, one might consider it to be a continuation of the AIRS measurement. Three-dimensional winds measurement with laser Doppler was a tier-3 Decadal Survey recommendation; ESA will fly a one-direction wind profiler in about 2-3 years. For NASA, this will occur in the post-2025 timeframe, informed by ESA results.

March 7, 2012

Dr. Huntress was absent due to illness, and Dr. Tapley sat in for Dr. Huntress.

Planetary Protection

Dr. Eugene Levy, Chair of the Planetary Protection Subcommittee (PPS) reviewed the principles governing NASA's policies on planetary protection, which is concerned with two types of protection. The first and most significant type of protection is control of potentially infectious agents coming to Earth, for protection of both humans and terrestrial biota; this is so-called back contamination. Planetary protection also requires that missions protect against forward contamination, which is important for accurately identifying life of independent origin, or life that has been transferred by non-anthropogenic means, extant on other bodies in the Solar System and beyond. The purpose of planetary protection is to enable scientific discovery and inhibit or reduce risk to the terrestrial population, not limited to astronaut health. Planetary protection policies and requirements are governed by international treaties that date to the 1960s, to documents originating in the US National Academies and the Committee on Space Research of the International Council for Science, and international space agencies. Public perception, particularly of back-contamination risks, could present an existential threat to any interplanetary return missions.

Dr. Levy reported on a recent joint meeting held by the PPS and the Planetary Protection Working Group (PPWG) (advisory to the European Space Agency, parallel to PPS). Dr. Cassie Conley, current Planetary Protection Officer, noted that the Europeans chose the meeting venue at Kennedy Space Center (KSC), specifically to view the facilities available for robotic missions planned for 2016/18. The meeting focused on general planetary protection matters, focusing especially on Mars sample return and the Russian/Chinese Phobos-Grunt mission. Among other topics, the meeting addressed the NASA/ESA joint Mars exploration programs, international science analysis group, a working group for a joint 2018 mission, Mars sample return (MSR) technical requirements, site selection, models of biocontainment facilities, and JPL studies. The meeting members toured the KSC facilities for spacecraft processes, visited labs and viewed procedures that focus on biological cleanliness.

Recommendations from PPS for transmission to NAC

The PPS and PPWG jointly recommended that NASA and ESA renew their Letter of Agreement to enhance their cooperation in closely coordinating their respective planetary protection activities, including technology development to enhance and advance planetary protection technologies.

PPS put forth a subsidiary recommendation (information only) regarding close cooperation between NASA and ESA as essential. PPS and PPWG exchange meeting minutes and hold joint advisory meetings at least every other year.

PPS also recommended for transmission to the NAC that a “lessons learned” report about the MSL project be carried out, noting that planetary protection report for the Viking spacecraft was a valuable resource for transmitting knowledge and practice to subsequent projects. PPS further recommended that the report be formulated while the MSL team is intact. PPS also noted the utility of a publication on the use of the ATP assay as related to standard assays for bioburden accounting, and research needed to determine the chances of liberating fluid in the presence of heat sources on the Martian tundra. NASA’s withdrawal from previous MSR mission planning makes the lessons learned report from MSL all the more important, as NASA likely faces a longer hiatus between Mars missions, constituting a threat to accumulated knowledge and experience.

PPS recommended to the Planetary Protection Program Office the establishment of an *ad hoc* subgroup that will review a study by H. Jay Melosh on samples from martian satellites, which indicated potential implications for returning Mars ejecta from the Mars satellites Phobos and Deimos; these materials fall under US planetary protection standards. The subgroups should produce results into terms of planetary protection and propose a way forward, and identify if there is a need for further analysis beyond Dr. Melosh’s findings. Dr. McComas asked how far PPS has gone in examining human exploration. Dr. Levy replied that the subcommittee has held only general discussions on the subject. Dr. Conley interjected that at the international level, there have been studies from the Space Studies Board (SSB) and the international group COSPAR, which have focused on developing guidelines. PPD has also been working with the Health Information Officer at NASA. Dr. McComas asked how MSR could pave the way for human exploration. Generally, the community feels that one must establish whether there are viable biota an astronaut could bring back from Mars, and what types of conditions could mimic an infection (e.g., the effects of sulfuric acid on lungs). Dr. Conley noted that monitoring of human commensal organisms is an essential component of human missions that is not needed for robotic exploration.

James Webb Space Telescope (JWST)

Mr. Rick Howard presented a status of the JWST mission, which is in the process of implementing a new baseline that was finalized in September 2011. The mission re-plan has provided adequate cost and schedule reserves. The FY13 budget request has provided full funding through FY17. Recent accomplishments: all flight optics have been cryotested and have met requirements. The Aft Optic System is complete and ready for its next testing regimen. Components of the primary mirror backup support center section are 94% bonded. The sunshield full-scale engineering test unit for layer #3 has been tested and looks good. Layer #5 has undergone some testing as well. Instrument deliveries will begin this Spring; the mission has developed a workaround to allow a third cryotesting session in the schedule, guaranteeing two cycles with all flight hardware.

The space craft CDR may be brought forward 6-10 months, buying more schedule flexibility and reserve; the program still have 13 months of funded schedule reserve on the critical path, which may be increased by another month.

Instrument deliveries have slipped. The ISIM delivery to OTIS slipped by 5 months (31 months to 26 months). Even with a detector change out, the program still has 11 months slack time for ISIM delivery to OTIS. Overall JWST has made great progress in FY11 and will continue to do so in FY12, achieving milestones within cost and schedule and executing to the new baseline. There are no new or unexpected issues. The mission is also taking advantage of heritage in techniques for deployment, using multiple test units with full-scale hardware. The mission has much commonality with previous large deployable systems.

The FY12 budget for JWST is \$529.6M, consistent with the re-plan. Mr. Howard briefly reviewed the master schedule, identifying some aspects of the critical path, and reviewed the status of the fine guidance sensor (FGS), NIRCcam, center Aft flight optics, and primary mirror optics. All mirrors are within specification for the composite figure, and have been fully tested. JWST hardware is entering a three-year period of integration and testing (I&T). Hardware for the telescope assembly ground support was installed at Goddard Space Flight Center (GSFC) approximately 8 weeks ahead of schedule. Milestones are being tracked and reported to the NASA AA and the center directors. Helium shroud walls are ahead of schedule. The MIRI instrument was delayed to 11 May 11 due to issues with optical alignment, and some verification of workmanship. Some additional vibration tests were performed, but there will be no impact on the overall schedule. The program is addressing issues with cryocooler valve leakage and is working on multiple paths to fix the problem. No schedule impact is anticipated, as a workaround is in place.

Mr. Howard reviewed activities for FY12, involving mostly system element I&T, and in response to a question described earned value management (EVM) practices in place at the prime contractor (Northrop Grumman). ITT is also using EVM. GSFC is installing an EVM-like system as well. Subcontractors have cost-incentive contracts in place, and there is also a more balanced system with respect to cost, performance and schedule. In 2012, cap language has also been introduced that will necessitate reporting any overrun as a full 30% breach.

Launch Services

Mr. Jim Norman, Director of Launch Services, presented a status from the HEOMD on launch services. HEOMD acquires launch services, and verifies and validates mission engineering and analysis. Last year NASA experienced a launch failure on 4 March 2011 for the SMD Glory mission on the Taurus XL launch vehicle, the second loss in a row for the Taurus XL. Neither the Orbital Science Corporation Accident Investigation Board nor the NASA Mishap Investigation Board (MIB) was able to find a root cause. Thus NASA has since terminated the Taurus XL launch service task order with Orbital Sciences for the OCO-2 mission due to the lack of a root cause finding, despite extra telemetry having been provided for the second Taurus launch. A summary report and corrective action plan are in progress. Mr. Norman was asked if NASA has considered using a truly external review to investigate the mishaps; he explained that the NASA MIB included external NASA members and included membership not part of the NASA launch services program.

After the 4 March 2011 Taurus failure, NASA conducted 5 successful launches in a 6-months period. Mr. Norman detailed how NASA contracts for launches through the NLS II contract, which uses multiple providers offering various vehicles. The vehicles are purchased on a firm fixed price basis, with an annual on-ramp feature that allows for new providers and/or new vehicles from current providers to be added. The contract currently includes Falcon 1 and Falcon 9 rockets, up to the Atlas V class. A vehicle can come onto the contract without having flown, however the vehicle cannot be bid without having had one successful flight. The Atlas V 400 and 500 series vehicles are certified, and the Falcon 9 has been flown but is not yet certified. The Delta II is certified, while the Athena II and Athena Ic are not yet flown nor certified. The Pegasus XL has been flown and certified. Cost ranges are: 1) small \$32-114M; 2) medium \$102M-136M; and 3) intermediate \$102M-334M. Prices have essentially doubled in the intermediate classes compared to the previous contract, NLS I. Delta II would be considered in the medium-class cost range, but a single purchase would be more expensive than the range's upper limit. The cost ranges represent rolled-up prices that include payload processing, downrange telemetry, and mission-unique services provided by the contractor. Price growth for the Delta II has been driven by infrastructure costs, which now must be maintained by ULA, and not the USAF or NASA.

There are unique characteristics for Delta II; it is not going into production, but ULA is providing assemblies for up to 5 vehicles. Professor Hubbard commented that the Deltas are only useful for polar-orbiting satellites since the remaining launch pad is at Vandenberg. Mr. Norman commented that there are additional cost challenges, noting that Atlas V prices are driven by suppliers and the industrial base. NASA will coordinate with the USAF and the NRO per the EELV MOU in order to maximize the buying power of the government. The USAF/DOD has a \$1B per year infrastructure contract, and NASA has been carrying a cost threat of an additional \$150M per mission, to be removed from the NLS II contract once the DOD and NRO agreement to continue to pay the EELV infrastructure costs is finalized. NASA did not have to pay this fee for MAVEN and does not expect to pay it in the future. There is also a crew surge cost risk; NASA expects this risk to normalize due to a full EELV manifest in 2012-14. MAVEN has a potential cost risk of about \$20M above the current contractual launch service price, to fit into an already crowded manifest for its November 2013 launch slot.

Launch Services Program Goals

NPP and MSL have successfully launched. On 30 August, RBSP will be launched on an Atlas V 401. NASA is supporting the IceSat-2 dual mission with the USAF. Launch Services has released a multi-mission request for two medium launch service task orders to support SMD missions, and to support NOAA's JPSS-1 satellite. Awards are expected in July 2012. Launch Services is supporting SMD and NOAA by presenting commercial launch options for JASON-3, and is working on assessments on new vehicles such as the Falcon 9 Block 1 and Antares. Any new flight of any new entrant (even outside NASA) is useful for information. Launch Services will continue to work with partners and customers and remains committed to mission success.

Discussion with the NAC Chair

Dr. Steven Squyres, the incoming Chair of the NAC, held a discussion with committee members. He viewed the "heavy lifting" process as being done at the Science Committee level, and viewed the NAC chairmanship as a means of bridging the committees to add value. With respect to recommendations and findings, Dr. Squyres felt the NAC could best help NASA with recommendations that are as specific and actionable as possible to improve the way the Agency does business. He expressed no intention of micromanaging the Science Committee. Just as he had intended in his work on the planetary Decadal Survey, he hoped to provide truly actionable advice to Agency. Dr. Squyres recounted that he did present Lessons Learned documents to the heliophysics Decadal Survey, with respect to decision rules. He also reported no changes in the advisory structure, and felt there would be no reason for a NAC Chair to impede sensible communication between the Science Committee, and the SMD AA and division directors.

Dr. Squyres hoped to be able to schedule a NAC meeting at least once per year to allow all the subcommittees the opportunity for some crosstalk. It might be useful, for instance, for the Science Committee to meet with the Human Exploration Committee, as well as to arrange other intelligent pairings for brief meetings. In response to a question, Dr. Squyres explained that all recommendations and findings must be brought to the NAC before NASA receives them, and agreed with the formality assigned to this path of communication. If there is important advice that the Agency should get, the NAC will not ignore it simply because the advice pertains to one small area. Important messages should be sent up to the NAC, after which the NAC can decide which recommendations should go to the Administrator and which should go to the Division Directors.

Discussion of findings and recommendations

Dr. Squyres heard concerns about the PSD budget cuts. As NAC chair, he fully recognized the cuts as a significant issue for the Agency, but allowed that a "flat" budget in the current environment is pretty good. Speaking as the former chair of the planetary Decadal Survey, Dr. Squyres promised to help translate the intent of the Survey: to provide a balanced program of planetary exploration that includes small, medium and large missions, recognizing that the most important missions are difficult and expensive. However, if a Division produces nothing but flagships, stagnation occurs. The Survey also tried to provide a set of decision-making guidelines to allow adjustments for declining budgets. Dr. Squyres reported being encouraged by the newly de-scoped Europa studies. The intent of the Survey recommendations are clear, and they represent the view of the larger community. Professor Hubbard

commented that he struggled to give actionable advice at a time when the budget has become too small to support even a balanced program. Dr. Squyres replied that the NAC could consider ways to alter the space science budget only if that were the consensus view of the Science Committee; a minority view is not actionable. Professor Hubbard suggested that maintaining the Decadal Survey's intent could include some mission that moves toward Mars Sample Return, particularly with respect to critical technologies whose risks need to be retired. Dr. Squyres agreed, but felt that the mission did not have to be the size of a MAX-C. There is currently a questionable capability to support communications for 2018-22 surface operations; PSD will need an asset in orbit to support Entry Descent and Landing (EDL) and data relays; these issues are compatible with Decadal Survey concerns. Professor Hubbard argued that the science case for sample return has been guided by carefully planned examination of objects in the Solar System, and that Mars is the next logical case for sample return. Dr. Squyres felt that the consistency of the planetary Decadal Survey has been quite clear, and that the Europa and Mars science cases remain the same.

Dr. Hinnert felt that there were additional factors that go beyond the science case for Mars, one of which is to take advantage of a capability built up over the last decade. Much capability will be lost without using it with some regularity. The Mars program will have to abandon high-priority science or re-learn painful lessons. At some point in the future, anticipating human exploration at Mars, sample return is crucial to determining when, how and if humans actually can get to Mars. Dr. McKinnon proffered the concept of launching a Mars telecommunications orbiter without a science payload, as a means of staying on the road to MSR. Dr. Squyres felt that such a mission that would be wholly consistent with the longer-range goal of sample return, provided there were thoughtful choices about orbit selection. Professor Hubbard suggested that one thing to be considered in addition to maintaining orbital assets would be the development of mature autonomous rendezvous and docking techniques. Dr. Squyres agreed that optical communications would also be welcome.

Dr. Tapley adjourned the meeting.

Appendix A Attendees

NAC Science Committee members

Wesley Huntress, Carnegie Institution, *Chair*
Byron Tapley, University of Texas, *Vice Chair* and Chair Earth Science Subcommittee
Alan Boss, Carnegie Institution, Chair Astrophysics Subcommittee
Noel W. Hinners, Consultant
G. Scott Hubbard, Stanford University
Eugenia Kalnay, University of Maryland
Eugene Levy, Rice University, Chair Planetary Protection Subcommittee
David McComas, Southwest Research Institute
William McKinnon, Washington University (representing the Planetary Science Subcommittee)
Robert McPherron, University of California, Los Angeles, Acting Chair Heliophysics Subcommittee
T. Jens Feeley, NASA Headquarters, *Executive Secretary*

NASA Attendees

Waleed Abdalati, NASA Headquarters
Marcus Allen, NASA Headquarters
Charles Bolden, *NASA Administrator*, NASA Headquarters
Scott Chandler, NASA Headquarters
Ellen Cohen, NASA Headquarters
Victoria Elsbernd, NASA Headquarters
Michael Freilich, NASA Headquarters
Dennis Gallagher, NASA Headquarters
Barbara Giles, NASA Headquarters
James Green, NASA Headquarters
Jeff Grossman, NASA Headquarters
John Grunsfeld, NASA Headquarters
J.D. Harrington, NASA Headquarters
Ilana Harrus, NASA Headquarters
Colleen Hartman, NASA Headquarters
Paul Hertz, NASA Headquarters
Debbie Hollebeke, NASA Headquarters
Rick Howard, NASA Headquarters
W. Vernon Jones, NASA Headquarters
Deirdre Jurand, NASA Headquarters
Lou Kaluziński, NASA Headquarters
Amy Kaminski, NASA Headquarters
Jack Kaye, NASA Headquarters
Jennifer Kearns, NASA Headquarters
Raymond Kinzer, NASA Headquarters
Tony Lawson, NASA Goddard
Lia LaPiana, NASA Headquarters
David Leisawitz, NASA Headquarters
Mike Luther, NASA Headquarters

Marian Norris, NASA Headquarters
Douglas McCuiston, NASA Headquarters
Michael Meyer, NASA Headquarters
Thomas Moore, NASA Goddard
Michael Moore, NASA Headquarters
Jim Norman, NASA Headquarters
Marion Norris, NASA Headquarters
Jeff Newmark, NASA Headquarters
Mario Perez, NASA Headquarters
Arik Posner, NASA Headquarters
Jonathan Rall, NASA Headquarters
Diane Rausch, NASA Headquarters
Andrea Razzaghi, NASA Headquarters
Lillian Reichenthal, NASA Headquarters
Rita Sambruna, NASA Headquarters
Wilton Sanders, NASA Headquarters
Eric Smith, NASA Headquarters
Heather Smith, NASA Headquarters
Linda Sparke, NASA Headquarters
George Tahu, NASA Headquarters
Glenn Wahlgren, NASA Headquarters
Michael Wargo, NASA Headquarters
Nicholas White, NASA Headquarters

Non-NASA Attendees

Linda Billings, GWU
Carol Christian, STScI
Anne Connor, House Science Committee
Randy Correll, Ball Aerospace
Dom Conte, Orbital Sciences
Tammy Dickinson, OSTP
Kathryn Flanagan, STScI
Bethany Johns, AAS
Brad Keelor, British Embassy
Joydip Kundu, OMB
David Lang, NRC
Bill Mackey, CSA
Michael Moloney, NRC
Larry Richardson, ULA
Marcia Smith, SpacePolicyOnline.com
Steven Squyres, Cornell University, *Chair NAC*
Enrico Vespericci, Visitor
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. Alan P. Boss
Carnegie Institution of Washington

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

Dr. G. Scott Hubbard
Stanford University

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. David McComas
Southwest Research Institute

Dr. T. Jens Feeley
Executive Secretary
NASA Headquarters

Appendix C Presentations

1. Science Mission Directorate Presentation to NAC; *John Grunsfeld*
2. Planetary Science Division Update; *James Green, Robert McKinnon*
3. Astrophysics Division Update; *Paul Hertz, Alan Boss*
4. Heliophysics Division Update; *Barbara Giles, Robert McPherron*
5. Earth Science Division Update; *Michael Freilich, Byron Tapley*
6. Planetary Protection Update; *Eugene Levy, Cassie Conley*
7. James Webb Space Telescope Status; *Rick Howard*
8. Launch Services Program Status; *Jim Norman*

Appendix D
Agenda

NAC Science Committee
March 6-7, 2012

Agenda
(all times EASTERN)

Tuesday, March 6 (MIC-3)

8:30-8:40am	Opening Remarks – J. Feeley / W. Huntress
8:40-9:00am	Committee Discussion
9:00-10:15am	Discussion with Associate Administrator – J. Grunsfeld
10:15-10:30am	Break
10:30-11:45am	Planetary Science / PSS – W. McKinnon / J. Green
11:45-1:00pm	Lunch on Own
1:00-2:00pm	Astrophysics / APS – A. Boss / P. Hertz
2:00-3:00pm	Heliophysics / HPS – R. McPherron / B. Giles
3:00-3:15pm	Break
3:15-4:15pm	Earth Science / ESS – M. Freilich / B. Tapley
4:15pm	Adjourn for the day

Wednesday, March 7 (MIC-7)

8:30-9:15am	Planetary Protection – G. Levy/C. Conley
9:15-10:00am	JWST Status – R. Howard
10:00-10:30am	Launch Services – J. Norman
10:30-11:00am	Discussion with NAC Chair – S. Squyres

NASA Advisory Council Science Committee Meeting, March 6-7, 2012

11:00-11:30am	Committee Discussion
11:30-12:30pm	Lunch on Own
12:30-2:30 pm	Findings and Recommendations
2:30-2:45pm	Second Day Wrap-up – W. Huntress / J. Feeley
2:45pm	Adjourn